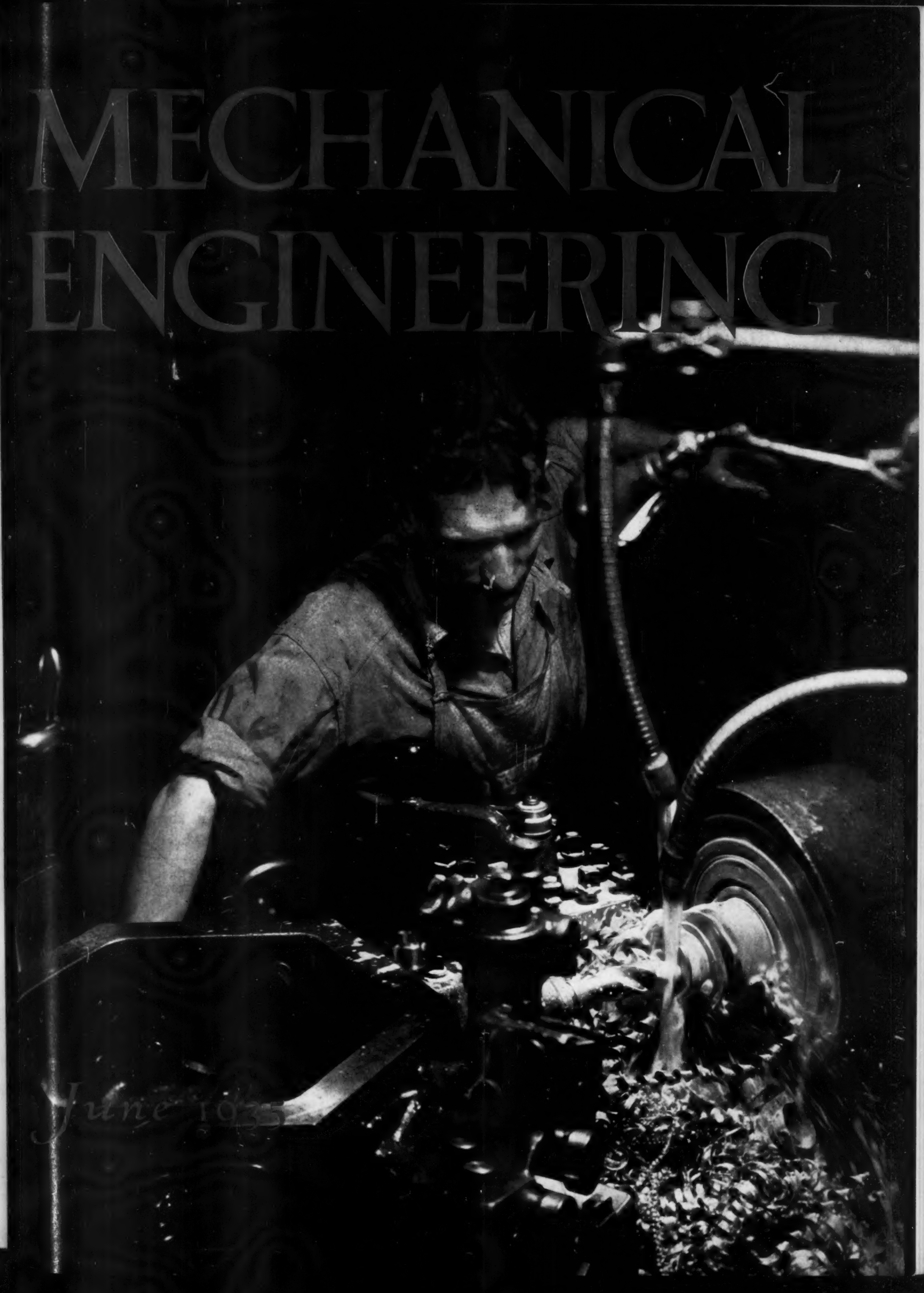
MECHANICAL ENGINEERING



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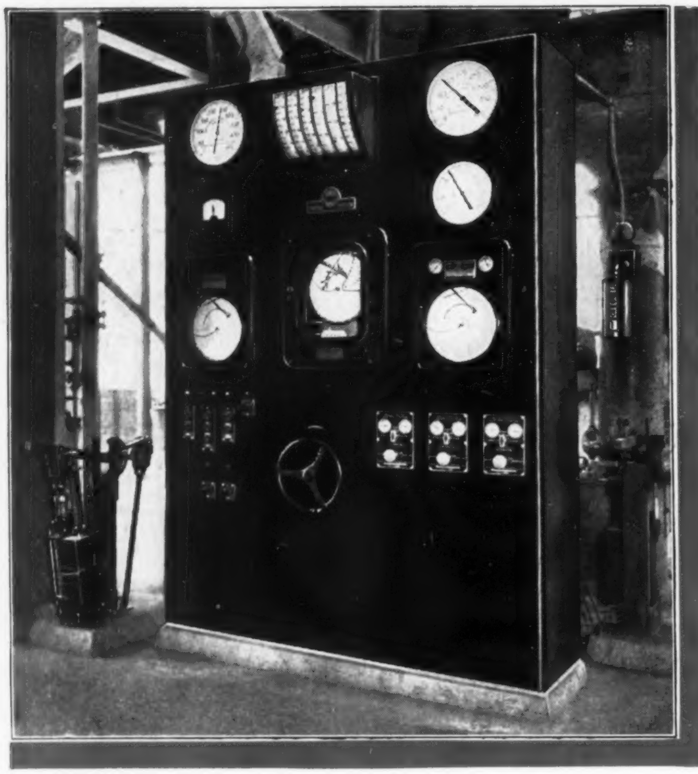

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MECHANICAL ENGINEERING

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MECHANICAL ENGINEERING

JUNE
1935

GEORGE A. STETSON, *Editor*

Cinematography in Research

ATTENTION is called to an abstract from a Japanese publication (page 379) dealing with an investigation of the motion of high-pressure powder gases and compression waves in the neighborhood of the muzzle of a rifle. The subject has already received careful attention from the military authorities of several countries and the investigation has been made possible by the availability of high-speed motion-picture cameras. Mechanical engineers are not primarily concerned with what happens when a rifle is fired, but essentially the same laws that control the motion of gases emerging from the muzzle of a rifle also apply to the flow from exhaust pipes. It is also possible that laws controlling the flow of steam and other fluids in mechanical devices will be found to be related to those resulting from these investigations and may be studied by means of cinematography.

McDonald Observatory Dome

IN a country where the production in great quantity of interchangeable parts and standardized articles, large and small, is highly developed, we are likely to forget that engineering design and construction technique are being applied in the building of structures, machines, and their appurtenances that are, in some cases, never again exactly duplicated. It is instructive, therefore, to look at one of these unique undertakings from time to time to see how its designers have utilized the principles and techniques familiar in other engineering products and to mark how the services of mechanical engineers are called upon in problems that present themselves only infrequently for solution.

An example of such an engineering project is afforded elsewhere in this issue in the article describing the dome of the McDonald Observatory and its operating mechanism. Without going extensively into detail, an attempt has been made to show some of the elements of the design that are of greatest interest to mechanical engineers. It is not likely that any considerable number of readers will be faced with the problem of designing a similar structure. However, there is profit in noting how another man accomplished what he set out to do, in passing judgment on his solution, and in pondering on alternatives that may present themselves to fertile-minded designers.

Professionally Sound Also

IN last month's issue a matter-of-fact statement of the financial condition of The American Society of Mechanical Engineers was placed on record. In the practical world of affairs the financial soundness of any undertaking is an indication of corporate health and an ability to accomplish the results for which it was organized. But gratifying as such a financial statement may be to all participants in the undertaking, particularly in times of economic disturbances, the financial figures themselves indicate little more than the value placed upon the enterprise by accountants and auditors. The larger and more significant values are those set upon it by the individuals of whom it is comprised and for whom its work is carried on. Many statements of these values have been made from time to time. One which recently came to our attention, made by P. L. Alger for the benefit of the A.S.M.E. Local Section at Schenectady, reflects so accurately the value of a professional engineering society to an individual that we reproduce it here with acknowledgment and appreciation to Mr. Alger and the hope that every one who reads it will cooperate in the work of the Society so heartily as to secure these values for himself and enhance them for others. The statement follows:

The advantages of membership which it seems to me should be stressed are three, of which the third is the most important.

TECHNICAL VALUE

Membership dues make possible publication and discussion of the technical advances in the art, without which American engineering progress would be greatly handicapped. Patriotism, therefore, suggests that those interested in engineering, even though not personally participating, should be members of some engineering society.

PROFESSIONAL VALUE

Being a member opens to you numerous services in the way of publications and standards, professional contacts, and employment service. Many times in your engineering career you will make use of your own and other engineering societies' services, so that a sense of responsibility urges that you carry your part of the expense by joining one of the societies.

SELF-DEVELOPMENT VALUE

The vitally important function of the engineering societies is to encourage young engineers to develop their technical and professional abilities by preparation and discussion of papers and by participation in public meetings.

Nearly every young engineer on first entering industry passes through a period of technical work, in which he has few contacts with other men and tends to become self-contained and narrow. In middle life, every engineer who attains important success must change from this technical field of work into one dealing largely with people. Unless, therefore,

he has maintained or developed the ability to speak effectively, to think on his feet, and to deal understandingly with all types of people during his initial period of technical work, the engineer reaches middle life with a tremendous handicap as compared with commercially and legally trained men. An engineering society affords the young engineer an opportunity to develop these abilities while he is still engaged in technical work, thus preparing himself for the future in a way he can never accomplish without the aid of engineering society opportunities.

Furthermore, in these days of specialization, every engineer's technical training should consist largely of getting acquainted with other engineers having specialized knowledge and thus establishing such mutual confidence that each can rely on the other's field of knowledge in handling the problems that arise. Thus, the opportunities offered by an engineering society to the young engineer in learning to know and to esteem other engineers will so greatly and rapidly extend the effective technical knowledge available to him that his professional advancement is greatly accelerated.

On this third ground alone, therefore, no young and ambitious engineer can afford not to join some engineering society.

No Substitute for Profit

IT IS A significant commentary on the unreality that characterizes many present-day beliefs and on the wide divergence that exists in social philosophies, that Colonel Ayres, of the Cleveland Trust Company, found it necessary to point out in an essay on business cycles recently prepared in response to a request from Senator Bailey, of North Carolina, chairman of a Senate Committee charged with the duty of studying the causes of the depression, that "any general change in the prospects of business profits may initiate a depression or a recovery."

If this statement is true—and it would seem to be so—those who seek to establish economic stability by doing away with the "profit motive" would seem to be on sound ground, but no sounder, their critics will agrue than that on which stand well-intentioned folk who would attempt to avoid fatal accidents among window washers by eliminating the law of gravity. For, viewing men as they appear in the world about us and as they are revealed in history, the hope of profit seems quite as universal a force in human nature as gravity is in the physical world. To carry this analogy further it may be recalled that the force of gravity serves faithfully and well those who understand its laws; and it is not too much to hope that the same may be said of the profit motive.

What we mean by profit may be subject to many interpretations. The term may be used broadly enough to cover any benefit or advance or progress, or so narrowly as to exclude everything but the money profit from individual commercial transactions. It may cover short- or long-term periods. It may apply to a given person or to society as a whole. It may be selfish or altruistic. It may be the reward of righteous and noble living no less than the clipping of coins by the money changer. We may examine its ethical or its economic significance, or we may attempt to reconcile both in a code of social conduct. In any event we must deal with it, and it is the part of wisdom to deal with it realistically and with understanding. We cannot eliminate it.

Colonel Ayres was speaking specifically of business profits in an economic system in which men engage in business with the expectation that they will reap more than they sow and in some few instances, perhaps, where they have not sown. To accomplish this—the former, not the latter—requires an intelligent use of numerous human virtues, and is a task not easy even under the most favorable conditions. The consequences of failure may mean such widespread human misery that closest attention should be constantly given to whatever factors may affect the prospects of business profits.

To such factors much attention is at present being given. But even here, alas, opinions differ and workings at cross-purposes frequently retard the rate of recovery if not recovery itself. For this reason Mr. Flanders' address on some neglected elements of recovery is particularly timely; and undoubtedly it will strike a responsive chord in the engineer's mind because its constructive features are closely bound up with the return of normal profits to enterprises in which a bulk of mechanical engineers are engaged.

The temptation to quote extensively from Mr. Flanders' address is great. He too recognizes the importance of business profits in recovery. His method of assisting recovery involves the use of more machinery. "An immediate return to our former enterprise in the application of improved machinery," he says, "will make possible that necessary decrease in prices without decrease in wages; will raise the standard of living; will raise the volume of business production; and will raise profits to the level required to support the industries producing these capital goods, whose workers are still largely employed."

Few engineers will fail to approve this statement, whether from self-interest in the industries to be benefitted, which they serve, or from an admission of its fundamental soundness. Conditions favorable to the return of business profits are favorable for recovery and employment. There is no substitute for profits.

Weapons of the Next War

IT WAS said long ago that the general staffs of the leading nations spent more time fighting over past wars than in developing the technique of coming conflicts. Ample evidence, however, is available to show that this is not the case today, and that if—or when—the day of wrath is loosed over the world, the technique of warfare will be vastly different from that employed in the last year of the World War.

The most essential feature of the new warfare will be the rapidity of mobilization. Germany was fully ready for the Franco-Prussian war, and yet more than thirty days were necessary for mobilization. About one-fifth of that time was necessary in the World War. In the next European war there will probably be no formal declaration, just as there was none in the Russo-Japanese war, but within two hours from the decision to go ahead the chief cities, railroad bridges, and fortresses east or west of the Rhine, as the case may be, will be in flames,

and within twelve hours from the same time a complete coverage of the frontiers will be accomplished.

When it comes to actual fighting certain tendencies are already clear. Trench warfare as a means of defense was not developed to its full extent until the World War. It was predicated, however, on the movement of the main armies in a horizontal plane. It is true that airplanes were used, but neither their number nor their size and efficiency made the flying arm of either side of major importance. As a matter of fact, neither side ever had more than one hundred planes in the air at any one time and those that were up were equipped with light machine guns or a limited number of bombs of small size.

In the next war it is probable that not less than several hundred planes will be in the air at any one time carrying projectiles weighing from 500 to 4000 lb. These will be protected by swarms of pursuit planes capable of speeds in excess of 250 mph, and equipped with machine guns of greater power and efficiency. Under these conditions warfare in the horizontal plane acquires, in Western Europe, at least, far less importance than before, and while such fighting will take place, the outcome will be decided elsewhere. It does not matter how strong the land armies of a combatant may be if the other side has sufficient superiority to obtain a certain amount of control of the air. The side which dominates the air will be in a position to cut off supplies of men, food, and ammunition from the land forces by means of a constant bombardment and will thus compel them to retreat.

Other possibilities in the use of the airplane are suggested by an unofficial report of a demonstration in Russia of the transportation of troops. Four glider trailers, each carrying an armed force, were detached from the towing plane and brought safely to land. By such means small but highly efficient and effective groups can be transported far behind the enemy lines. Upon landing, the troops can attack and destroy strategic structures and cripple important services before resistance can be organized. A hundred well-armed men can cause considerable damage to power houses, railroads, and manufacturing plants before they are killed or captured, and by seizing automobiles, they can swiftly broaden the area of their operations.

In land warfare itself a factor of paramount importance is becoming clearer and clearer. This is the superiority of defensive over offensive means. At the end of the World War it was recognized that unprotected infantry cannot take by storm a place fortified by a sufficient number of machine guns, particularly when these machine guns are located in proper emplacements. The answer to the machine gun in a concrete pillbox was supposed to have been found in the tank, but with the present possibilities of guns firing bullets with muzzle velocities in excess of 3000 ft per sec, enlarged Stokes mortars, and, particularly, highly mobile, small, high-speed cannon, tank armament for a while ceases to offer effective protection.

These observations, of course, apply principally to a war fought in Western Europe. If the war happens to swing to the east of the Vistula rather than to the west of the Rhine, conditions will be different. The distances become very much greater between the enemy factions on the east, and the destruction, for example, of such cities as Kiev or Pskoff, will produce a scratch rather than a mortal wound, and will irritate rather than substantially weaken.

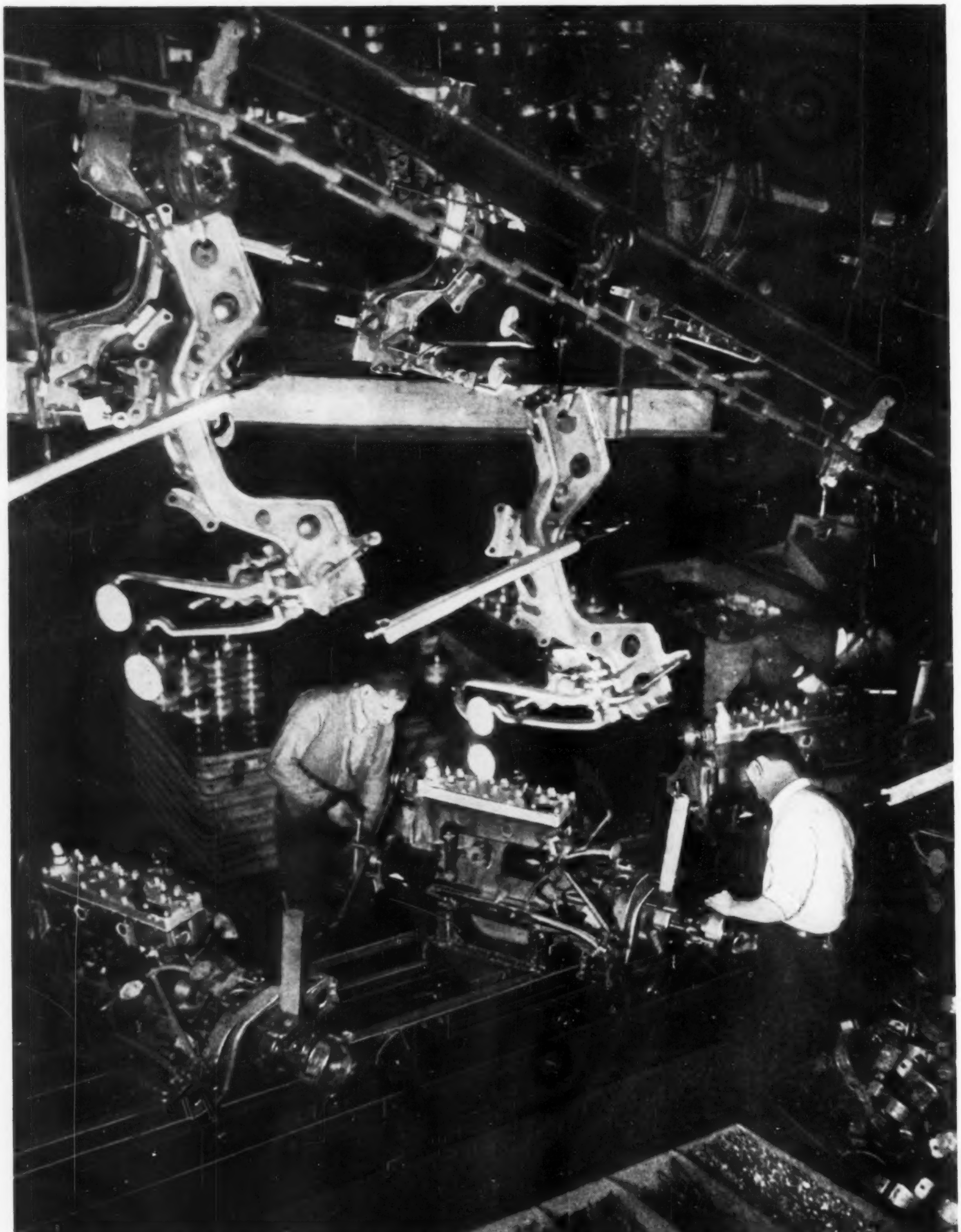
One basic feature of the next war is likely to be the non-existence of neutrality. The attack on the man behind the man behind the gun frankly seems to be a legitimate procedure because of the close connection that the country back of the fighting line, with its production facilities, has with success or failure on the battlefield. The slogans of 1917 and 1918 about winning the war by raising wheat clearly indicate this disappearance of the true distinction between the civilian population and the army, and if the man behind the man behind the gun happens to be an innocent noncombatant, it's too bad for him, but does not change the assumed legitimacy of indiscriminate attack on the civilian population of the enemy.

This attack may take several forms. It is hardly true that a city like Paris or London can be wiped out in one attack from the air, but with the air fleets available it is perfectly possible to drop from 50 to 100 tons of arsenic trifluoride, mustard gas, or lewisite. If such an attack were repeated three, four, or five nights, the population would still not be wiped out, but the life of the city would be neither healthy nor pleasant. It may be comforting to picture the whole family, including the cat and baby, in gas masks, but one cannot talk or eat or drink in a mask, and mustard gas may be effective a week after it has been dropped if rain or snow has not fallen in the meantime.

The picture of biological warfare, often painted, in which bombs are dropped from the sky, burst on reaching the ground, and fill the air with germs of anthrax or bubonic plague, thus wiping out the population of a city in a week, is a product of an overactive imagination. Cholera germs dropped into water supplies will not necessarily create an epidemic, because of present methods of water treatment and control, yet they may produce a considerable amount of sickness. But dropping a ton or so of some kakodyl compound or butyl mercaptan into even a sizable lake will give the water a smell that will make it undrinkable; and neither the chlorine treatment nor ultra-violet ray purification affect the noisome qualities imparted to the water.

It would appear, therefore, that by the application of sound engineering and chemistry to such a crude art as warfare, humanity has achieved a remarkable enhancement of efficiency in the art of killing, and if the signs are read aright, the next two years will see the same frantic pursuit of military research that characterized the last two years of the World War.

In the light of such possibilities, one can earnestly wish for the preservation of peace and international sanity, and the removal of as many of the causes of war as are in the control of individuals and governments.



Ewing Galloway, N. Y.

Men and Machines—Assembly Line in an Automobile Factory

Neglected ELEMENTS OF RECOVERY

An Inquiry Into the Relations Between Agriculture and Industry, Prices and Wages, Governmental Expenditure and Income, and Recovery and Reform

By RALPH E. FLANDERS

PRESIDENT THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

TWO years of the New Deal have passed into history. Two more years lie ahead of us. It is time to take stock of its achievements and failures. Has it been so successful that its continuance and development are desirable? Is its failure so manifest that the arousing of political opposition becomes a public duty? Or does the appraisal indicate neither unquestioned success nor utter failure, but that result more usually found in human affairs—a mixture of achievement and error, of hopes a little realized and much deferred?

A rapid survey reveals many items of progress. The prices of agricultural products have been raised, and the farmer has become a more active customer for the products of industry. Employment has increased above the low point and wages have been raised throughout the whole extent of industry. The volume of production has grown. All the business indexes have advanced. The number and seriousness of business failures has notably diminished.

But—agricultural recovery was induced by means which are generating serious reactions, and those means cannot safely be applied for another two years. Wage-rate increases are being eaten up by a rising cost of living. The decrease in failures is a natural unmanaged result of survival of the strong and fit through a period of stress. The business indexes have flattened out in the last year, and show some obstinacy about approaching the very moderate levels of 1931.

Most ominous of all, the improvement in employment took place almost entirely in the first six months of the New Deal. There has been little progress since. Particularly is it true that the greatest body of unemployment—that in the building trades and construction industries—remains unimproved and immovable. That sullen total of eight to ten millions of unemployed faces us week after week, month after month, year after year, whatever may be the state of prosperity of the employed. It poses to us the question of the sphinx. If we do not find the answer, we perish.

All that can be done by blind courage and messianic faith has been done. All that can be done by ingenious and novel economic political expedient has been done. If the President, if his Administration, if the New Deal are to go down in history as having found effective solutions to problems which are momentous on the epic scale, a new attitude, a new approach, must be added to those already applied. The policies of novelty, ingenuity, and improvisation must be reinforced by qualities drawn from experience and common sense.

I venture to suggest some of these needed elements of experience and common sense. For convenience I have divided the problem into four sections, of which the first concerns the relations between agriculture and industry.

AGRICULTURE AND INDUSTRY

The fall in value of farm products was one of the principal phenomena of the depression, and, by inference, it was considered to be one of the principal causes. Three measures were taken to raise the prices of farm products: devaluation of the currency, marketing agreements, and decreased production subsidized by government grants in part from processing taxes.

Of these measures the monetary one was expected to raise the general price level. This it did to a slight degree only, except in the case of commodities whose price is set by world markets. As might have been expected, our devaluation has been met by progressive devaluation by our principal competitors in world markets, and seems impending for all of our customer nations as well. Devaluation is a game that all the world can play at, as it has and will. Its advantages are short lived.

The crop control, live-stock destruction, marketing agreements, and processing taxes have been more successful so far as concerns the immediate purpose of raising the prices of farm products. They have been less successful in secondary results which might have been foreseen, which were, in fact, foreseen by intelligent, unemotional observers.

One of the undesirable effects is the loss of a large part of the foreign market for many of our farm products, cotton being the most seriously affected. Really, was there any excuse for ignoring the recent experience of Brazil in her attempt to control the coffee supply and enhance its price? Why should it not be expected that new cotton areas would be developed and stimulated, as new coffee plantations were? The same thing that is happening to cotton is happening to wheat and lard in a somewhat less degree.

The maintenance of a higher domestic price means that the industrial worker is taxed to raise the farmer's income. This is only excusable on the assumption that the industrial worker is better off than the farmer. Sad as the lot of the latter has been, it would be hard to prove that he has been as helpless and as incapable of

Presented at a meeting of the Metropolitan Section, New York, N. Y., May 1, 1935, of The American Society of Mechanical Engineers.

self support, where drought has not been involved, as the city dweller has been in the past five years.

There is something more than injustice involved here. It is a matter more of impossibility than of injustice. These high prices cannot much longer be borne. Already the processing tax on top of the price of cotton is destroying the market for domestic cotton cloth. Mills are shutting down, workers are laid off, and cotton accumulates. Here is one of the tangible elements in our unsolved problem of the unemployed.

What we seek is a solution which does not tax the worker to support the farmer, or burden agriculture to maintain industry. What we seek is a solution which benefits both. The first requirement is a new balance between agriculture and industry, based on the relative demand for the products of the two occupations. There is an insatiable appetite, an unfilled demand of enormous proportions, for the products of industry. There is a corresponding possibility of expanding demand for agricultural materials which go into manufactured goods. But for foodstuffs, which constitute the main product of agriculture, the demand, while capable of further expansion, is ultimately limited by the normal human appetite. As a consequence, a return to our old success in raising the general standard of living will involve an increase of industry relative to agriculture—a resumption of the normal migration from farm to factory, rather than a continuance of the present unhealthy reverse movement. In the revival of industry and a consequent drain on the agricultural population lies the hope for a natural, effective balance. If agricultural output ought to be limited, this is the way to do it. We must not permit our temporary dosing with stimulants to interfere with our ultimate recovery, as is now the case.

Even on the short-range solution, agriculture depends on industry. Return to a normal standard of living will expand markets to a point where moderate prices and greater volume will give a larger net farm income than the present artificial conditions can provide. This is particularly true for dairy products.

If industry depends on agriculture, as was the original New Deal thesis, so does agriculture depend on industry, as hard experience teaches. There really is no primacy in this matter. The two are indissolubly bound together. In our country neither can prosper at the expense of the other. There is a way for them to prosper together from this time on, without perpetuating the temporary and dangerous stimulants now being applied, and without interfering with a return to a natural balance. This is by way of a determined reduction in the price of manufactured goods, which will at once stimulate employment and reduce the cost of what the farmer buys, thus raising his standard of living. This brings us to our second topic, prices and wages.

PRICES AND WAGES

Here we are concerned with the NRA rather than with the AAA. A body of harmful practice became intrenched in code making and administration, and in other activities of NRA as well. There was, on the part of industry, organized labor, and the Administration, from the first beginnings of the original act, an idea that recovery, reemployment, and a raised standard of living would result from a carefully balanced increase in prices and wages. That idea was fallacious and has delayed recovery.

There is no man, no group of men, having the infinite intelligence and wide-spread power required so to manipulate a rise in wages and prices as to produce a recovery. In all past times recovery has come when lowered prices stimulated consumption, and the reappearance of profits stimulated expansion and reemployment. The rise of wages and prices has come as a natural result of recovery, not as an impossible cause.

The higher standard of living we are looking for is one that is higher even than that of 1929, which was pitifully low as an average for the mass of the population. A rise in the standard of living means that prices and wages move relatively in *opposite* directions, not together; and in the face of foreign competition and of the remaining disparity between agricultural income and prices of manufactured goods, our choice—if we have a choice—will be for prices to move down rather than for wages to go up. This is the direction which lowers rather than raises tariff walls. This is the direction which stimulates sales and employment. We are suffering from the inherent difficulty of trying to expand business with a price level raised in advance of demand and recovery, rather than because of demand and recovery.

The lowering of prices is as good for the wage earner as a rise in wages. It is better, for it makes more work. A rise in wages tends to raise prices and make less work if work is already scarce.

To summarize, present prices do not give the desired standard of living to the worker on the one hand, nor on the other do they furnish a broad enough market or a sufficient profit to the employer to expand operations and employment. Raising prices without raising wages is not feasible, since it still further diminishes sales for the employer and lowers the standard of living for the worker. Improving the standard of living by raising wages without raising prices is impossible in view of present narrow profit margins. Improving profit by lowering wages without lowering prices is so evidently impossible that it is unnecessary to consider it.

The only remaining possibility is to lower prices without lowering wages. This raises the standard of living and will greatly stimulate the demand for goods. But how is it possible to do this in view of the aforementioned narrowness of the profit margin? One answer is that this narrow margin might be preserved by the larger scale of operations and the consequent economies. This probably applies to some of the companies producing construction materials. To other industries it will seem to be a forlorn hope indeed.

But, the real answer to the problem of a simultaneous increased business output, increased profit, increased employment, and a generally raised standard of living is the answer that shallow theorists deride, shortsighted labor leaders combat, and timid industrialists avoid.

The real answer lies in a renewed and continued application of more efficient labor-saving machinery. Properly applied, this remedy makes possible the seemingly impossible. It lowers prices and raises profits without lowering wages. This is the end we must attain. There is no other means within our power for attaining it.

Better machinery and methods have been the answer of the past. They alone have raised the mass of the population above the level of primitive agricultural subsistence. They alone have given millions of workers the bath tub, the radio, and the automobile. They alone will continue to provide these and newer comforts, and to extend them to millions of families now deprived of them. An immediate return to our former enterprise in the application of improved machinery will make possible that necessary decrease in prices without decrease in wages; will raise the standard of living; will raise the volume of business production; and will raise profits to the level required to support the industries producing these capital goods, whose workers are still largely unemployed.

We need have no fear of thus returning to our old confidence in labor-saving machinery. We have never yet, on a fifty-hour week, produced goods in a great enough profusion to give a decent standard of living to the average worker. The best of modern equipment will have to be built and installed and put to work on an enormous scale if the desired standard of living is to be possible on a forty-hour week; and here again is the means by which, when we recover our courage, we shall liquidate another of the great blocks of unemployment, that which is found in the equipment industries.

But this return to our former initiative in the installation of new equipment requires a return to our old-time courage and dependence on private enterprise. This return is made difficult by a number of factors, one of which constitutes our third topic. This obstacle to recovery is the distrust of the developing situation in governmental expenditure and income.

GOVERNMENTAL EXPENDITURE AND INCOME

Could we put ourselves into the state of mind of only three years ago, our present situation would be incredible. Since March, 1933, in little more than two years, our Federal Government has appropriated more money than in its entire previous history from the signing of the Constitution to the beginning of the World War, including the cost of the War of 1812, the Civil War, and the Spanish-American War. This incredible expenditure leaves us unconcerned, on the whole. We eat, sleep, make love, and tend to business as we always have. Who would have predicted our comparative complaisance in the face of this extravagance? Was our old psychology dull and unenterprising? Or is our new state of mind tinged with insanity?

It is not merely that we are spending enormous sums; there is an incredible aspect to the means by which we are raising them. They are not being raised by the taxation of profits. There are no profits sufficient to support taxation on the grand scale of our expenditures. They are not being borrowed from the savings of the people. The resources of these savings were long since exhausted. The billions being expended are simple extensions of credit—a bookkeeping process by which, under continuous unremitting pressure of Government and of circumstance, banks are persuaded to take Government paper and in return write down with typewriter or pen and ink certain figures which permit the Government to draw checks for these easy billions. The processes of liquidating this credit will not be so easy.

I said that this incredible expenditure left us unconcerned—that we go about our business as we always have. That is not quite true. There is a faint odor in the air of something not quite as it should be—some element of disease or decay rather than of health. The business man hesitates to venture, to expand, to risk his funds or his credit on expanded employment. There is doubt in the air. Funds no longer flow freely into new investment. That there remains a market for Government paper at low rates—on more favorable terms than for private investment—is no contradiction to the fact of uncertainty. Where all is doubtful, where all is uncertain and indistinct, the Government is, perhaps, the best of all doubtful chances, the least of all prevailing evils. Particularly is that so when the Government has successfully arrogated to itself the power of life and death over private business, and seems not at all averse to using that power in its full strength. What wonder that utility and industrial and railroad bonds continue at a discount, while new private investment and reemployment hesitate and fail of becoming effective? What wonder that Government bonds alone attain and maintain a handsome premium?

All of this brings us to the fourth subject of this discourse, which is the vexed problem of recovery and reform.

RECOVERY AND REFORM

Reform has been, and is being, somewhat blindly directed against profits; and because this is being done, our mass of unemployment must continue, and our enormous expenditures for relief must accumulate.

Consider that appropriation of $4,880,000,000 for two years of relief—$2,440,000,000 per year. It is the greatest appropriation ever made by any government at any time. Yet it is pitifully inadequate for the needs of our millions of unemployed. What the unemployed need is the normal $12,000,000,000 to $15,000,000,000 of profit and savings flowing into needed new investment each year, not a beggarly governmental dole of $2,440,000,000 per year.

A sum which endangers governmental credit and yet is inadequate, can be multiplied *five times* and taken by private industry in its stride, if private industry is encouraged to make its normal profit and apply that normal profit to its normal use in maintaining employment in the industries which are now depressed.

We need not fear that these profits resulting from the installation of new equipment will themselves interfere with our healthy progress. Business profits—that is, profits from the production and distribution of goods

and services—have never been too great for the needs of financing the equipment for our rising standard of living. It is "profits" of another sort which have repeatedly thrown us into business confusion and social disintegration. What we have to fear and control is speculative profits, and particularly the inflated bank credit (that is, unpayable debt) on which such profits are based. Here lies the major problem of business stability.

It is not the *amount* of profits that destroys, but the *kind*. But it is the amount of profits that the Administration has set its face against. If one member of the Administration renders lip-service to the profit system, another attacks it directly or by inference. If irresponsible and undisciplined members of the Administration chance to be silent, powerful legislative interests set about the making of laws which will destroy profits and perpetuate unemployment. And if underlings and legislators alike chance to be silent, the Chief Executive himself gives clear indication that the fight is still on against business profit and consequent reemployment.

Let me give a specific instance. Again and again the Administration has attacked the utilities, both in their corporate structure and as to their rates. *In both respects the utilities are vulnerable.* Their rates are of importance to consumers. They might, in some instances, conceivably be reduced in amounts which would reduce the bill of some household consumer by sums ranging from $15 to $50 per year. There is, in other words, the same opportunity for increased efficiency, lowered prices, and increased consumption for the utility that there is for other industries we have been discussing—not much less, not much more.

But the utilities affect the common man in other ways. In the building-up of their corporate structures during the boom period, in the emission and sale of pyramided securities, in the credit inflation which supported these pyramided securities, lay the seeds of the boom that ended in 1929 and of the dismal years which followed. Here was a phenomenon which has cost many a family, not $15 to $50 annually, but years of unemployment and a lifetime of savings. The legislation for controlling that catastrophe is already on the books in the form of the Securities and Exchange Acts. The continuous hammering on the minor element of rates, but particularly the way in which it is done, is delaying reemployment.

The TVA "yardstick" is the weapon. It is a weapon, not a yardstick. It is not a carefully constructed measuring instrument, but a knotted club, studded with spikes, with which the Administration lays about itself lustily and recklessly.

If the TVA rates indeed constituted a yardstick, calculated, under the public eye, to set a real measure of proper cost of electric current to the public, then private initiative and capital could flow into a field which remains an attractively profitable one, even if "rich pickings" were outlawed. But this is not the situation. The governmental yardstick being flourished by emotion instead of being constructed and applied by reason, there is no surety of return for investment in utilities. As a consequence, we have stagnation in a field which should be active. Last December the output of electric current nearly approached the all-time record. Next December it may break that record. Under normal circumstances there would be increasing activity in power-plant construction and thus increasing employment of those now unemployed. But the TVA club is flourished and private initiative and funds seeking investment all run for shelter. The Federal Power Commission plaintively wonders that there is no new construction. The unemployed are quaintly surprised that they have no work. Not reform, but recovery—that is what will save the lives and the souls of the unemployed.

The essentials of reform are nearly complete, and their completion constitutes the valid and unparalleled achievement of the New Deal. These essentials are to be found in the hour and wage provisions of the NRA, which set a subsistence minimum below which the competition of depression will not be permitted to submerge the worker. They are to be found in the Securities and Exchange Acts which, with all their crudities, yet furnish the means for the control of speculative inflation, and the consequent prevention of severe depression and unemployment. Only one essential element is still lacking, a banking law which will give to our credit-money system a control which is exercised in the public interest, not in the interests of the political needs of a transient administration on the one hand, nor in the interests of speculative greed on the other. With this problem solved, we have all the reform we now need and can now assimilate. From this point on our task is not reform, but recovery and reemployment.

The necessary processes are not difficult, not incomprehensible, not arduous. As they have been outlined in the preceding paragraphs, they are seen to consist of old and useful practices to be returned to, rather than of novel expedients to be rapidly experimented with, discarded, and thrown aside.

We live in a time of rapid change. We may not be able to decrease the rapidity of that change, but we can give direction to its movement. Backward we cannot go. The nations which have moved to the right and left have attained results far below our possibilities. The ups and downs we must mitigate, and already we have constructed the controls for this purpose.

The remaining direction, the preferred direction, is rapid movement straight forward along the path we have been following for generations into the new blessings which may become a part of our country's destiny—"May become," I say, for this destiny is merely possible, not inevitable.

If industry, if labor, if finance, if Government—above all Government—get a clear picture of the course and bend their efforts to following it, that destiny will be realized. The American people will continue that old course, but with fewer interruptions, toward more continuous employment, higher material standards of living, and new spiritual experiences.

McDONALD OBSERVATORY DOME

A Description of a 62-Foot Dome and Its Operating Mechanism

By E. N. JENNISON

THE WARNER & SWASEY COMPANY

ONE of the most prominent features of an astronomical observatory is the dome that houses the telescope. Such a dome is not merely an architectural ornament but serves various practical purposes in connection with the operation of the observatory, and, for that reason, its construction differs widely from that of the usual dome. The following description of the 62-foot dome that is to house the 82-in. reflecting telescope of the McDonald Observatory on Mt. Locke, in western Texas, outlines the requirements of observatory domes in general and indicates how these, and the special requirements of this observatory, have been satisfied. A view of the observatory is shown in Fig. 1.

The diameter of an observatory dome is determined largely by the optical dimensions of the instrument that it shelters. There must be space enough to permit moving the telescope tube into any position without interference and there must be an opening or slot in the dome considerably wider than the diameter of the tube and affording an unobstructed field of vision from horizon to zenith. In the 82-in. McDonald Observatory telescope, the ratio of length of tube to diameter is somewhat less than is usual in reflecting telescopes, hence a dome having an outside diameter of 62 ft was found to be of sufficient size. However, the slot required to accommodate a reflector 82 in. in diameter, a 16-ft clear opening extending 9 ft past the center of the dome, must be of unusual width for a dome of that diameter and adds in a like degree to the difficulties to be overcome in providing a sufficiently rigid structure, since the dome is thus more than half divided by a slot one-fourth its diameter. Some idea of the proportions of the dome, the slot, and the shutter can be obtained from Fig. 2. Other requirements affecting the design are shutters to close the slot, two fabric curtains independently movable lengthwise of the slot to protect the instrument from air currents, an observing bridge spanning the slot and movable so as to follow the outer end of the telescope from horizontal to vertical, counterweights for the bridge, and a stairway affording access from the floor to the bridge regardless of the position of the latter. All this must be carried on the dome structure and the dome must be arranged to be rotated so that the slot may face in any direction. Most of these elements are shown in Fig. 3.

The dome structure consists of a base ring mounted on trucks and supporting two main ribs which are semi-circular arches across the base ring, forming the sides of the slot. These ribs are connected near the top by a deep girder, forming the end of the slot, and at the bottom by the base ring and beams carrying platforms at opposite sides of the ring. Secondary ribs of lighter section extend from the base ring to the main ribs and are uniformly spaced except where interrupted by the slot. Between these ribs is the framing that carries the inner and outer covering of the dome. It may be stated here that the object of this double covering is to provide space for a circulation of air up through the dome. Air enters the hollow walls of the circular building on which the dome is mounted through louvers in the outside at the ground level and, passing upward, is led into the hollow wall of the dome from which it escapes through louvers at the top, the joints between the movable dome and the substructure consisting of sheet-metal guards forming a short horizontal passage of sufficient section. The framing between ribs is made up of straight members and the dome, therefore, is not a hemisphere, but a 24-sided figure, which avoids the use of warped surfaces in the covering.

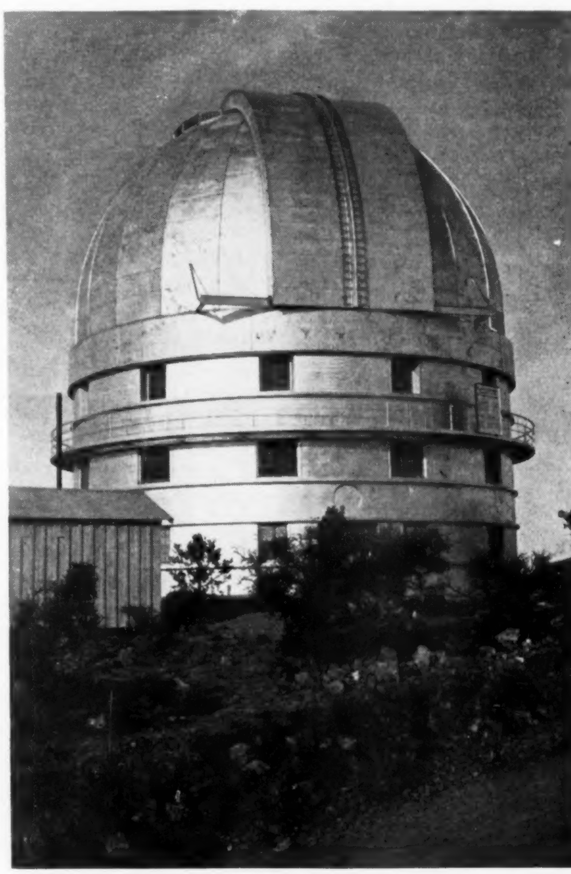


FIG. 1 MC DONALD OBSERVATORY, MT. LOCKE, TEXAS

BASE RING

The base ring consists of two 10-in. channels spaced 18 in. back to back with webs vertical and flanges facing. These are bent to form a ring of 29 ft 6 in. inside radius, and to the outer channel is attached a 6-in. channel with the web horizontal, which adds stiffness to the ring and helps to support the brackets that carry the vertical skirting that covers the joint between the dome and the substructure. The base-ring channels are connected at frequent intervals on top by plates to which the ribs are connected and on the bottom by welded frames carrying the trucks that support the dome, the truck wheels entering the space between the channels.

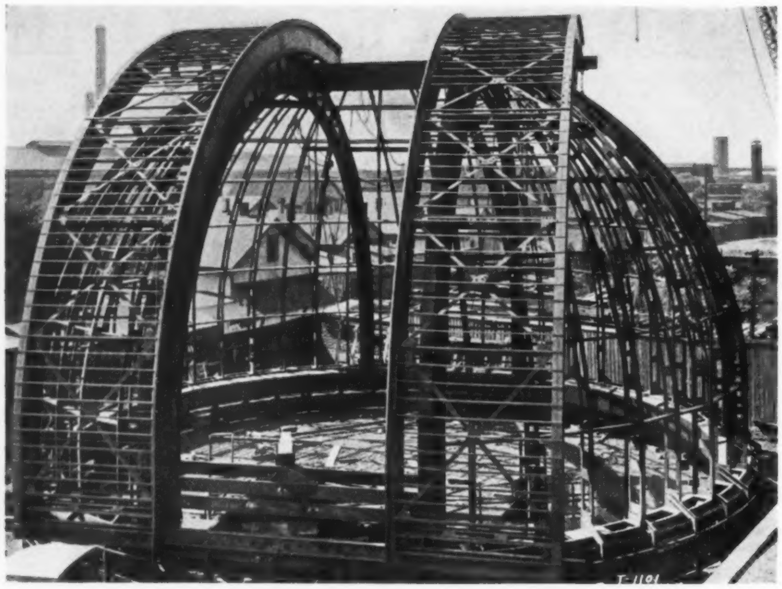


FIG. 2 SKELETON OF OBSERVATORY DOME ERECTED FOR TESTING

TURNING CABLE

The dome is turned by an endless cable carried in a circular track attached to the inside of the dome, from which it is led over two sheaves, mounted on the wall of the substructure, to the driving mechanism on the floor below the observing floor. The mechanism is illustrated in Fig. 5. This consists of a motor-driven sheave having two grooves and a counterweighted take-up sheave, the latter carrying the cable between its passes under the double sheave thereby taking up slack and insuring constant tension. The track is made of a $3^1/_2$-in. by $3^1/_2$-in. angle bent to form a circle 57 ft 2 in. in diameter, carried by rigid brackets attached to the ribs of the dome just above the base ring. At intervals on the angle track are cast-iron blocks grooved to fit the cable as a precaution against slipping. The turning motor is rated 5 hp and drives through a worm-gear reduction, which, with the additional reduction between sheave and cable track. This gives a turning speed which amounts to one revolution of the dome in four minutes, approximately.

TRUCKS

The entire weight of the dome, estimated at 125 tons, is carried on 26 trucks, shown in Fig. 4, each carrying a stationary shaft on which is mounted a single wheel 30 in. in diameter with a pair of roller bearings in the hub. The wheels are of high-test nickel cast iron of ample section and the treads are turned to a slight taper, so that the wheel forms a section of a cone having its apex at the center of the dome, no flange being provided. The track rail being formed to the same angle, a normal rolling action is thus assured. Since the greater part of the load comes on the main ribs, the trucks are not equally spaced but are so arranged that two come under each end of both main ribs. The load on these trucks is estimated at 17,000 lb each, the remainder being distributed among the other trucks which are, however, of the same design.

TRACK

The track on which the dome is rotated consists of a single 80-lb T-rail of standard section except that the top is machined to a slight angle as already noted. The rail is bent accurately to a radius of 30 ft 3 in. and is made up in twelve sections, with the ends machined to a close joint and doweled. This track is supported on 48 cast-iron track plates designed to hold the rail securely in position but providing vertical adjustment for leveling, the plates at the joints in the rail being arranged to support both sides of the joint. Cushions are inserted under the track plates to reduce the transmission of noise to the substructure when the dome is turned.

SAFETY DEVICES

At twelve equidistant points on the base ring are mounted heavy brackets carrying guide wheels that bear on both sides of the head of the rail to oppose any tendency of the truck wheels to leave the track, and, as a precaution against any possible lifting of the dome in case of severe wind-storms, the brackets also carry a double hook fitting over the head of the rail and close to the web, the absence of fish-plates at the joints permitting this construction. The guide wheels are mounted on anti-friction bearings and the hooks are swung on pins so that they cannot drag on the rail.

MAIN RIBS

The principal members of the dome are the two main ribs which form the sides of the slot. These are plate girders in the form of circular arches of 26 ft 4 in. inside radius with a vertical run of 4 ft 9 in. below the spring line. The web is $^3/_8$-plate 46 in. deep along the slot and 36 in. deep beyond, stiffened with 3-in. by $2^1/_2$-in. angles spaced about 3 ft apart. The top chord is made up of a 6-in. by 6-in. and a 6-in. by $3^1/_2$-in. angle, giving a total width of about 10 in., while the bottom chord consists of two 8-in. by 6-in. by $^1/_2$-in. angles with a $^3/_8$-in. cover plate 16 in. wide. As these ribs were unsupported on one side for more than half their length, it was necessary to take special precautions against lateral deflection due to the load imposed by the thrust of the secondary ribs, and the wide bottom chord also served as a track for the trucks that carry the observing bridge and its counterweights. The ribs are spaced 18 ft from center to center and are carried down to the base ring to which the outer chords are attached. The inner chords, however, come well inside the ring and are carried by 10-in. channels that extend across the ring at right-angles to the slot, a construction that adds to the rigidity of the structure and distributes the load over a wider section of the base ring. An additional connection between the main ribs at the lower end of the slot consists of four 10-in. channels, arranged in pairs, which also serve to support some of the mechanism for operating the bridge and shutters.

At the upper end of the slot, 9 ft past the center of the dome, the main ribs are connected by a girder consisting of two 15-in. channels, one above the other, with webs vertical, the lower being stiffened by two 12-in. channels attached horizontally to form a box girder between the ribs. The upper channel extends 9 ft 6 in. beyond both main ribs to provide a track for the upper end of the shutter, the outer ends being braced to the dome structure. To provide sufficient connection between the main ribs, which are separated by the slot for more than half their length, a system of lateral framing is inserted in the space between the upper cross-girder and the base ring. Apart from the main ribs, the structure of the dome consists of ribs curved to give the proper contour to the dome but much lighter in

section than the main ribs. These ribs, connected by channel braces, alternate with a set of still lighter intermediate ribs that support the covering on the flat sides of the dome. At the lower edge of the dome a cylindrical skirting 4 ft 8 in. high is carried by brackets attached to the secondary ribs and extends well below the base ring. The inner and outer coverings of the dome are carried without interruption down these brackets ending in a horizontal passage formed of overlapping plates that provides for the circulation of air from the substructure to the movable dome and serves as a weather guard as well.

The outer and inner surfaces of the dome are covered with 22-gage galvanized Toncan metal except at the top where the outer covering is of 18-gage to permit walking on it when inspecting the upper shutter mechanism. The covering is fastened to the girt angles by sheet-metal clips that are folded into the seams.

SHUTTERS

The slot opening is closed by two shutters, each consisting of two deep plate girders curved to match the contour of the dome at the edge of the slot and connected to form a rigid structure. Each shutter is carried on four trucks, having a 10-in. wheel and two guide rollers, all on anti-friction bearings. The upper trucks run on the track formed by the cross-girder at the upper end of the slot, and the track for the lower end is a 12-in. I-beam attached to the base ring below the slot with the ends suitably braced. The outer and inner covering on the shutters is the same as on the dome; the outer covering is attached to 2-in. by $1^1/_4$-in. angles spaced about 12 in. apart. A ladder extends the full length of each shutter on the side toward the joint. Weather protection consists principally in sheet-metal guards arranged to overlap similar guards on the outside of the main ribs so as to form a labyrinth when the shutters are closed. Further protection is provided by guards fitted closely around the tracks and one shutter carries a trough that projects under the joint to catch any leakage through the labyrinth at that point. Each shutter is provided with screened louvers at top and bottom to permit circulation of air as in the dome. The shutters are operated simultaneously by means of cables attached to both ends, brought down from the top of the dome over sheaves attached to the main ribs and passed around a drum driven by a 2-hp motor which moves the two shutters weighing 16 tons each at a speed of ten feet per minute.

OBSERVING BRIDGE

One of the observing positions on a reflecting telescope is at the distant end of the telescope tube. But here the astronomer must have just as easy access to his eyepiece or photo-

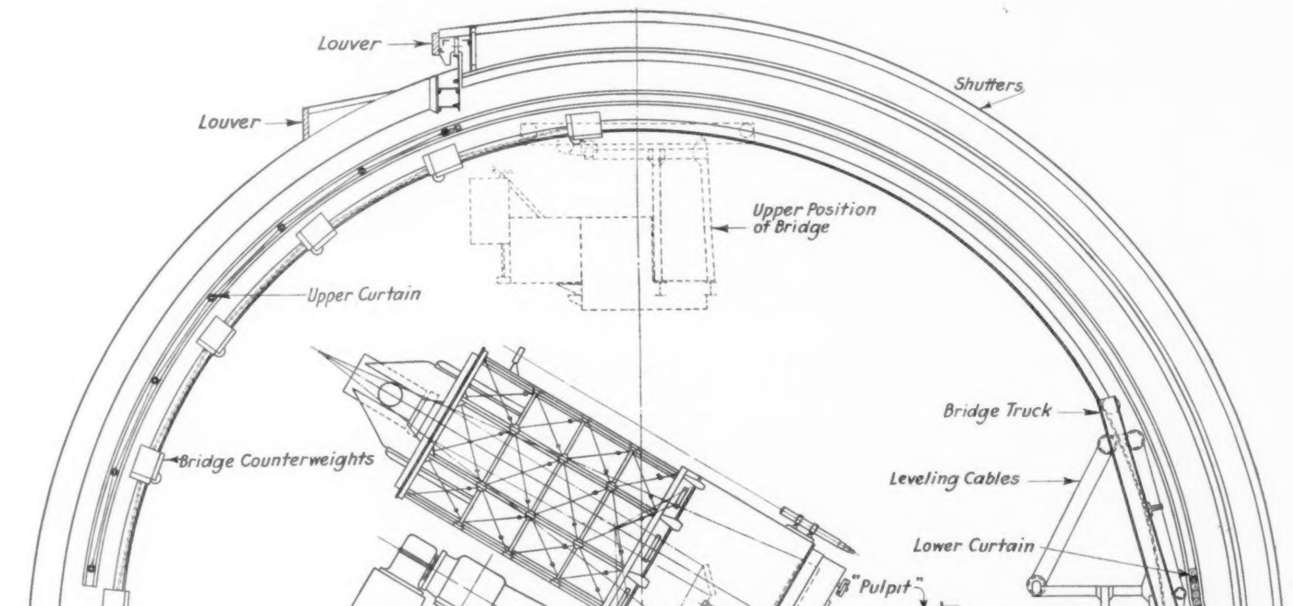


FIG. 3 GENERAL VIEW OF DOME, SHOWING OUTLINE OF 82-IN. REFLECTING TELESCOPE AND ITS OPERATING FEATURES

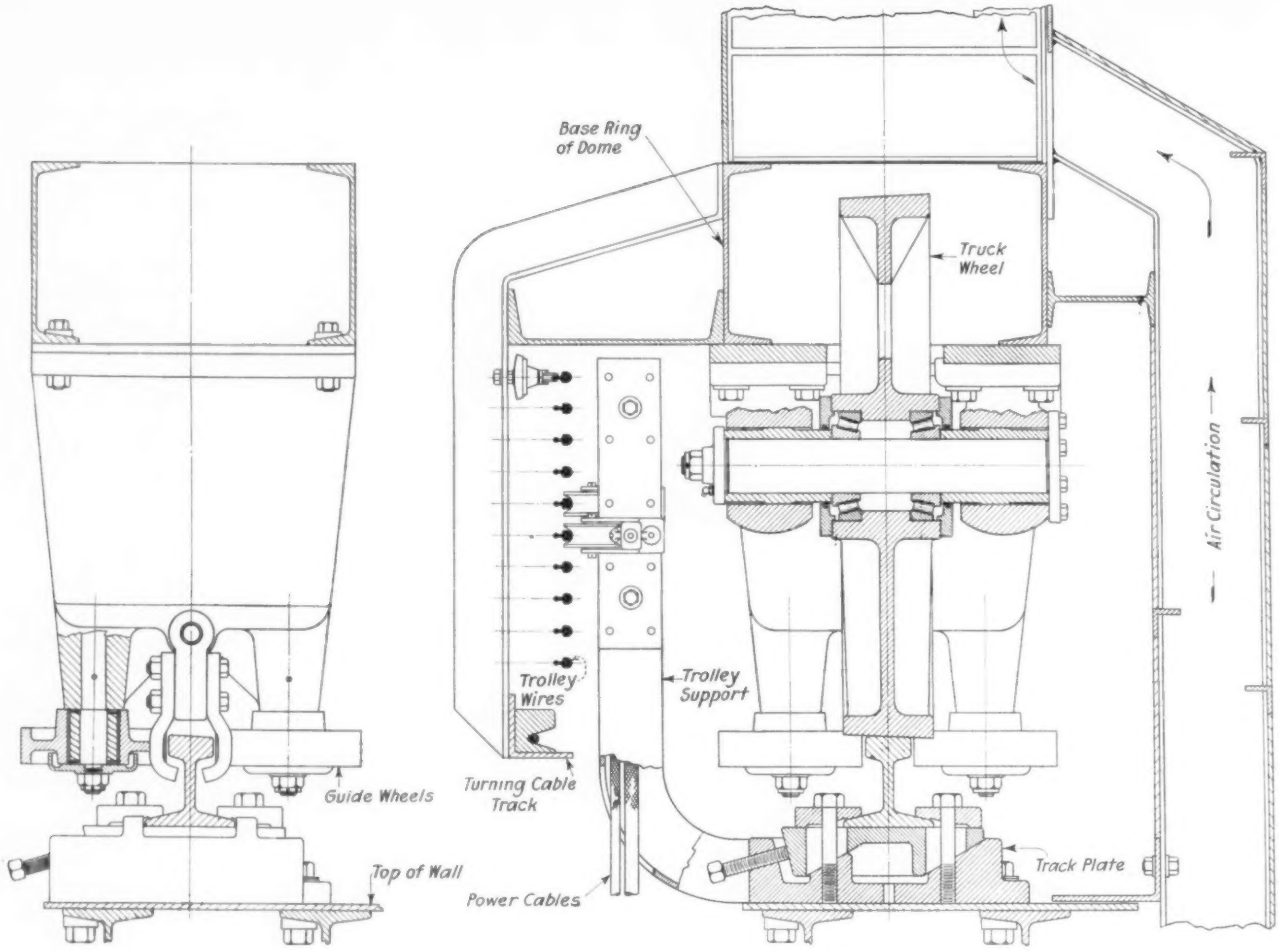


FIG. 4 MAIN TRUCKS AND GUIDE WHEELS

graphic plate as in the lower positions. In order to reach this position, the dome is equipped with a bridge, see Fig. 7, that spans the slot and is suspended from trucks that run on the lower chord of the main ribs. At its lowest position, at the lower end of the slot, it is 14 ft above the floor, but as the trucks follow along the main ribs, the bridge travels upward and in toward the center of the dome until it reaches its maximum height at the upper end of the slot 36 ft above the floor.

The bridge consists of a platform 3 ft wide extending across the slot and projecting beyond the main ribs at either end. At the right-hand end an extension perpendicular to the bridge terminates in a vertical ladder, rigidly supported, affording access to the stairway that leads to the floor, which would otherwise be inaccessible at some of the lower positions of the bridge. At the opposite end is a counterweight to equalize the load.

The bridge is carried by two rectangular frames of structural material which are suspended by pin joints from trucks arranged to run on the lower chord of the main ribs. The steel castings carrying the suspension pins are attached to the upper member of the frames close to the rear, while the forward ends extend inward beyond the bridge to support sheaves for the leveling cables that keep the bridge horizontal as it travels up the curve of the main ribs.

The trucks that carry the bridge are made up of deep channels with an I-beam spacer. At each end of the trucks are two 10-in. flanged wheels with anti-friction bearings that run on studs projecting inwardly from the side channels. The trucks have a wheelbase of 11 ft. At the lower end is the bracket for the suspension pins and at the upper end are the sheaves for the leveling cables.

The bridge is raised and lowered by cables, one for each truck, attached to a bracket on the upper flange of the side channel that comes on the side of the main rib toward the slot. Each cable is attached by means of a turnbuckle for equalizing the length, from which it is led over a guide bracket to a series of small sheaves mounted on the web of the main rib. These carry the cable to a take-up sheave near the upper end of the slot from which it is led over a similar series of sheaves to the lower end of the main rib where it is guided around a sheave at right angles to the rib to a motor-driven drum. After several passes around the drum it is returned to the main rib and is led over guide sheaves to the truck where it is made fast. The same cable therefore serves for hoist and downhaul, the latter being necessary because the bridge is counterbalanced, and since the cables for both trucks are wound on the same drum uniform operation is assured. There is also one leveling cable for each truck. This cable is fastened, with an equalizing turnbuckle, to the main rib near the lower end of the slot and is led over guide sheaves to the truck where it passes back and forth several times between the truck and the supporting frame of the bridge over the groups of sheaves already mentioned, being finally made fast to the truck. As the truck moves up the rib and approaches a horizontal position, this cable, being

fastened to the rib, opposes the motion of the truck and thereby tends to shorten the distance between the groups of sheaves, the number and location of which have been carefully chosen so that the bridge will remain very closely horizontal regardless of its elevation.

As an additional convenience in reaching the upper end of the telescope tube when it is vertical, the bridge is provided with two extension platforms projecting inward perpendicular to the bridge, and each arranged to be movable, independently, from its respective end of the bridge to the middle.

The platforms are supported by cantilever frames extending back under the bridge and carried on rollers that permit the platforms to be traversed along the bridge. The width of the platforms is 5 ft along the bridge, narrowing to 2 ft at a distance of 4 ft from the bridge. The narrow part of the platforms is pivoted and may be swung parallel to the bridge or extended to a maximum of 9 ft 3 in. At the extreme end a section called the "pulpit" is raised 8 in. above the bridge level and is equipped with hand-operated screws that afford an additional 20-in. elevation at the will of the observer. The entire platform is surrounded by a sheet-metal wall of sufficient height to provide ample security, at the same time adding to the rigidity of the structure.

The platform is swung by means of a circular rack attached to the fixed part and a pinion on the swinging part driven by a roller chain from a vertical shaft at one side of the pulpit, while a similar shaft on the other side operates the elevating screws, the handwheels for both motions thus being readily accessible. The traversing motion along the bridge is provided by a motor on the under side of each platform. These are gear motors with a pinion on the low-speed shaft that engages a rack on the front edge of the bridge, the total reduction being such as to give the platform a speed of 10 ft per min. Portable push-button stations permit the control of this motion from any point on the platform and limit-switches prevent over-travel.

There is a pipe railing all around the bridge. Along the front this consists of a series of self-closing gates arranged to be swung back over the bridge to afford access to the movable platforms at any position. The pair at the middle of the bridge are somewhat longer than the others and, when swung back, give ample clearance around the telescope tube when the bridge is close underneath it, at the same time enclosing this part of the bridge so as to prevent any one from inadvertently approaching the unprotected edge. The weight of the bridge complete with movable platforms is approximately 6 tons. The hoisting motor, already mentioned, is rated at 5 hp and drives through a worm-gear reducer, giving the bridge trucks a lineal speed of 10 ft per min.

BRIDGE COUNTERWEIGHTS

In order to maintain a fairly constant load on the hoisting motor, the bridge is provided with an equalizing counterweight system. This consists of a series of weighted cars running on the lower chord of the main ribs on the side opposite the bridge, connected one above the other by sections of chain, with the upper car attached to the corresponding bridge truck by two cables, one on each side of the rib. The arrangement is such that, with the bridge in its lowest position, all of the cars are suspended by the cables, and the total weight is equal to the deadweight of the bridge. It is evident that as the bridge travels upward along the arched rib the load on the hoisting cables will decrease, hence less counterweight is desirable to avoid overhauling. The cars, therefore, are so spaced that as the bridge rises, the cars come to rest, the lowest against a stop and the others against the car below at such intervals as to avoid danger of overhauling the bridge or overloading the hoisting motor. The cars are built up of structural material, in the form of two sheet-metal boxes, one on each side of the ribs, large enough to contain 275 lb of punchings and leave space for a pan in which the chain from the car above may coil when the cars are in contact. There are five cars on each rib with a total weight of approximately 1200 lb each.

CURTAINS

To protect the telescope from air currents that might cause optical disturbances through vibration of the tube or in other ways, the slot in the dome is equipped with two curtains of weather-proof fabric, independently adjustable along the slot so as to leave only the opening necessary for observing. These are carried on tubular supports which span the slot and have on either end grooved rollers that run on a track attached to the web of the main ribs. The track is made of two flat strips bent on edge, so arranged that the rollers run between them as a precaution against displacement of the curtains by gusts of wind. The rails are carried by brackets that project from the main ribs far enough to clear the operating cables which are attached to the brackets that carry the rollers at the ends of the curtains and pass over guide sheaves to the operating mechanism on the machinery platform at the lower end of the slot. The upper curtain has a down-haul cable that is attached to the lower end and passes over take-up sheaves at the far side of the dome, but the lower curtain merely hangs in folds at the lower end of the slot as its rollers come in contact. Chains connecting the tubular supports relieve the fabric of strains due to hoisting. The cables for operating the two

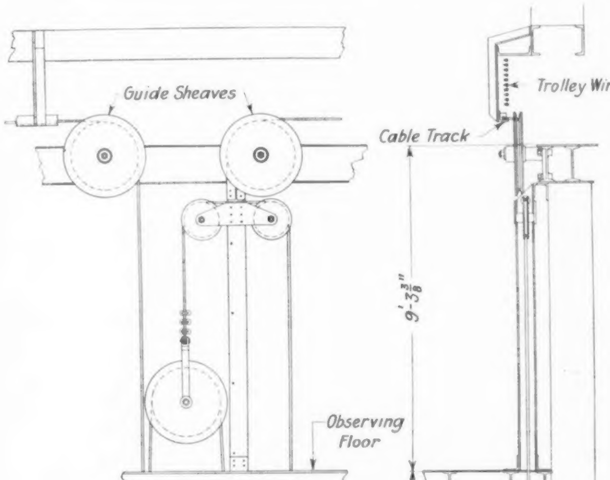


FIG. 5 MECHANISM FOR TURNING THE DOME

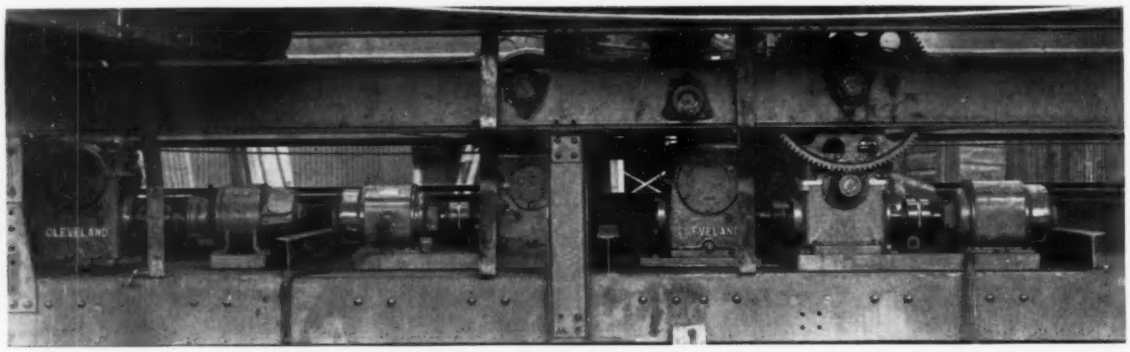


FIG. 6 MOTORS AND REDUCING GEARS FOR ELEVATING AND LOWERING OBSERVING BRIDGE, OPERATING WIND CURTAINS, AND OPENING AND CLOSING SHUTTERS

curtains are wound on separate drums driven through worm-gear reducers by 2-hp motors.

STAIRWAY

In order to provide access to the bridge, regardless of its position, a stairway is suspended from the dome parallel to the slot and close to one end of the bridge. By following quite closely the curve of the dome, it has been possible to maintain sufficient head room and at the same time preserve the necessary clearance below the stairway, while keeping within an easy step of bridge level through the greater part of its travel. A sheet-metal wall on the side away from the bridge and a pipe railing in the form of a series of self-closing gates that swing back over the stairs insure safety in the use of the stairs, which is further increased by a continuous hand rail and checkered floor-plate stair treads.

CONTROL

The motors for operating the bridge, shutters, and curtains are mounted on a platform at the lower end of the slot, see Fig. 6, accessible from the bridge at its lowest position. Each motor is mounted on a bedplate with its reducing gear which it drives through a flexible coupling. A thick layer of cork is inserted between the bedplate and the platform to reduce noise when running. The necessary electrical apparatus is located as near the motors as it may be and is connected by a flexible cable to a control station on the bridge, where a master-switch enables the operator to control any of the motions and also to turn the dome.

In addition, the bridge and dome motions may be controlled from portable push-button stations on either of the movable platforms that extend from the front edge of the bridge. At certain points on the observing floor there are similar master-switches for convenience in controlling the shutters, curtains, and dome when observing at the lower end of the telescope. Connection to the motors on the dome is made through ten trolley wires attached to the brackets that carry the track for the turning cable. The wires consist of galvanized steel bars of figure-eight section, forming continuous rings, mounted on insulated supports. A bracket, mounted at a convenient location on the wall of the substructure, carries ten bronze trolley wheels which are held horizontally against the wires and complete the circuits for control and power supply. A sheet-metal guard attached to the inside of the brackets prevents accidental contact with the wires.

FIG. 7 OBSERVING BRIDGE, SHOWING DETAILS OF SUPPORTING MECHANISM

Influence of PROTECTIVE LAYERS *on the* LIFE OF METALS

By FRANK N. SPELLER

NATIONAL TUBE COMPANY (SUBSIDIARY U. S. STEEL CORP.)

IT IS well known that most metals suffer more or less deterioration through reaction with their environment. This may result in surface corrosion or internal disintegration of the metal. Examples of the latter are dezincification of brass and the so-called graphitic corrosion of cast iron. It is also well known that the tendency to corrode varies greatly between different metals and with the same metal in different environments.

Where water is present the mechanism of corrosion is electrochemical and is controlled by many factors, some of which affect the initial reaction of solution of the metal or its tendency to corrode, and others the rate of deterioration over a long period of time. The latter group in this sense have been termed secondary factors to distinguish them from the primary factors that have to do only with the initial tendency. The secondary factors are often very important as they usually determine the ultimate useful life of the metal.

The many factors involved, the various types of corrosion, and means for prevention have been discussed elsewhere and, therefore, will not be referred to in detail here.[1]

CLASSIFICATION OF CORROSION TYPES

The corrosion problem is now recognized not as a single one, but rather as a group of problems complicated by many variables, the resultant of which determines the rate of attack. In view of the fact that factors external to the metal usually predominate, it was found convenient to classify corrosion according to the environment and we now speak of it as atmospheric, under-water, soil, or chemical corrosion, or electrolysis due solely to stray electric currents. While there are many factors involved in each type of corrosion, usually one or another exercises the controlling influence. For instance, in atmospheric corrosion the predominant factor is moisture; in water, the oxygen concentration; in soil, the electrical conductivity, total acidity, drainage, etc. Some special problems apparently do not fit into this classification. In some petroleum products water is but slightly soluble, yet the free oxygen may amount to 30 parts per million or more (about five times the amount present in sea water under normal conditions). Therefore, where gasoline containing oxygen is stored in steel tanks and pipe lines and water is present on the surface of the metal, the conditions are highly favorable to corrosion, since the oxygen in the gasoline is transferred to the water. In this case (as in atmospheric corrosion) an excess of oxygen is available. Therefore, in gasoline pipe lines the controlling factor is the amount of moisture in the gasoline, which is usually quite limited. Probably the most economical remedy in such cases is to dehydrate the gasoline.

PRINCIPAL FACTORS AFFECTING RATE OF CORROSION IN WATER

The principal factors affecting the rate of corrosion in the presence of water are listed in Table 1. They have been grouped in this manner to indicate conveniently whether they are associated mainly with the metal or the environment.

TABLE 1 PRINCIPAL FACTORS AFFECTING CORROSION IN PRESENCE OF WATER[2]

Factors associated mainly with the metal	*Factors which vary mainly with the environment*
Effective electrode potential of a metal in a solution	Hydrogen-ion concentration (pH) in the solution
Overvoltage of hydrogen on the metal	Influence of oxygen in solution adjacent to the metal
Chemical and physical homogeneity of the metal surface	Specific nature and concentration of other ions in solution
Inherent ability to form an insoluble protective film	Rate of flow of the solution in contact with the metal
	Ability of environment to form a protective deposit on the metal
	Temperature
	Cyclic stress (corrosion fatigue)
	Contact between dissimilar metals or other materials as affecting localized corrosion

Some of these factors, such as the standard single-electrode potential and homogeneity, affect the *initial* rate, while others, such as temperature, velocity of flow, and available oxygen, more often determine the *average* rate at which the corrosion process proceeds; and still another group, which includes mainly concentration cells and contact effects, determines the *distribution and localization of corrosion*. The latter frequently results in penetration of the article before the metal has lost 5 or 10 per cent of its weight.

METAL SURFACE FILMS

Space does not permit a discussion of all the dominant factors, but as films are evidently of fundamental importance to the life of metals they will be referred to in more detail.

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[1] "Corrosion—Causes and Prevention," by F. N. Speller. Second edition. McGraw-Hill Book Co., 1935.

[2] Factors that control the rate of corrosion may also be classified according to their influence on the anodic or cathodic reaction. For instance, the former is stimulated when the corrosion products are dissolved, peptized, or are permeable to ions; while the latter is stimulated by free oxygen (the most common cathodic depolarizer), or by materials in contact with the metal that lower the overvoltage and facilitate the liberation of free hydrogen. A discussion of the mechanism of corrosion along these lines will be found in a paper by Evans and Hoar, "The Mechanism of Metallic Corrosion," Trans. Faraday Society, vol. 30, no. 156, part 5, May, 1934.

The environment, as a rule, influences both the actual and relative rate of corrosion of a metal much more than the ordinary variations found in the metal. It has been demonstrated that all base metals such as iron, copper, aluminum, etc., acquire a surface film when exposed to air at normal or elevated temperatures, and that it is usually the resistance of this film that determines the life of the metal rather than some internal property, in as much as the metal itself usually does not come into direct contact with the attacking medium. Protective surface films are formed by reaction between the metal and its environment, usually by oxidation. The materials essential for film-building may originate mainly in the metal or in the environment, as in passivation with nitric acid or chromates; or both metal and environment may contribute their share in building the film, as in stainless steels.

Metals, such as chromium, nickel, copper, and aluminum form highly resistant films in some environments but not in others, and when alloyed with iron in solid solution have the power of conferring on it some of their film-building power according to the amount of alloying elements present. Chromium is the most useful of these metals, and, when alloyed in the proper amount and correctly treated, ferrous alloys are obtained having superior physical properties combined with high resistance to corrosion. The determination of the amount of film-forming constituents that will give the maximum corrosion resistance to iron at the lowest cost is a promising but difficult field of research.

In referring to unsolved corrosion problems last year[3] the author referred to the problem of metal surface film as follows:

> The study of the formation, structure, and protective properties of metal surface films and the nature of their bond to the metal is one phase of this problem, the solution of which may be of far-reaching importance, for corrosion is usually a problem in surface reactions. To afford permanent protection it is, of course, essential that films be self-healing when injured. This is another property that requires more investigation. Further study of protective metal film may also help to produce better artificial coatings. For instance, the failure of paints and certain metallic coatings usually starts at pinholes. In certain environments small imperfections in coatings have been found clogged with corrosion products, and in such cases the coating has shown a much longer life. It has been suggested that the bare metal and coating material may perhaps be designed so that the initial corrosion products will seal discontinuities in the coating.[4] This suggests another promising field for research.

In discussing the relatively simple problem of oxidation of steel at elevated temperatures, Dr. Johnston has raised the following questions which apply equally well to the whole problem of film protection.[5]

> The information now available furnishes little indication of what would be a logical procedure in a search for a ferrous alloy highly resistant to scaling at elevated temperatures. The obvious requirements are that the alloy should form a closely adherent surface film of oxide, and that this film should be nearly impervious to the passage of oxygen atoms inward or of metal atoms outward; but as to the implications of these requirements, one can raise questions which can be answered only by specific investigation. For instance, does close adherence of scale imply that the pattern of the metal atoms in the scale film is nearly identical with the arrangement of those metal atoms in the surface skin of the specimen? Or even that there is one network of metal atoms common to both scale and metal surfaces at the interface? Or does it imply merely that the effective expansion coefficients of scale and metal in the plane of the interface must be nearly alike? Should the alloying element have a high rate of diffusion through the iron matrix, so that it comes rapidly to the surface to heal up imperfections in the scale? And must it be more readily oxidizible than iron, as are chromium and aluminum? Is a highly impervious oxide layer one in which oxygen or metal is almost insoluble? Is it an oxide of a metal which forms a single stable oxide, as aluminum oxide, rather than of a metal such as iron with its several oxides and oxide mixtures? And, is it likely to be a compound oxide, such as a spinel? How far is the success of the protective skin determined by the character of the very first element of the film formed on the metal surface? On questions such as these, knowledge is at present largely or entirely lacking; until some of them are answered, one is limited to purely empirical tests, most of which are certain to be unsuccessful.
>
> The answer to these, and similar questions, must await further investigation of the how, why, and wherefore of films on metallic surfaces. Such investigations would throw light not only upon how to develop the best protective film on each metal, but also upon what really constitutes a good adherent coating, whether of paint or metal, put on by dipping or by electroplating, or of enamel.

The influence of various kinds of metallic crystalline architecture on the bond and stability of metal surfaces might be another interesting field for investigation.

The stability of films has been found by Vernon[6] and Evans[7] to vary materially with the conditions of initial exposure. When the environment is very favorable to the formation of a dense adherent film, unusual resistance to corrosion has been obtained even with ordinary wrought iron and steel, which admittedly are vulnerable under usual conditions. This fact seems to explain the long life occasionally found with old wrought iron and steel.[8]

Several cases have been reported where, on removal of the initial corrosion products from well-preserved iron and steel and exposure of the clean surface to ordinary air, rust developed rapidly. The nature and stability of metal surface films are now considered to be among the most important factors determining the course of corrosion. Local differences of potential due to concentration cells or contact with dissimilar materials may be sufficient to break down the film and cause pitting, even on stainless steel. Therefore, it is essential in running extensive corrosion tests to draw time-rate curves so that the trend can be studied and predicted beyond the limits of the test period. Frequently, the rate of attack decreases and sometimes corrosion ceases altogether after a certain time, due to the formation of a protective layer of inert materials on the metal (Fig. 1). If the latter did not take place, the life of most metals would be much shorter.

MEANS OF PROTECTION IN GENERAL

Prevention of corrosion has usually been accomplished in general by (1) improving the inherent resistance of the metal; (2) changing the environment; and (3) isolating the metal from destructive environment. In the last analysis all of these depend upon the formation of a resistant protective layer of some sort that will retard or stop the corrosive process. In a

[3] "The Corrosion Problem," by F. N. Speller, Howe Memorial Lecture, A.I.M.E., February, 1934.

[4] Op. cit., p. 1.

[5] "Corrosion Problems," by John Johnston, *Industrial and Engineering Chemistry*, Dec., 1934, p. 1240.

[6] W. H. J. Vernon, (*a*) "Investigation of the Atmospheric Corrosion of Non-Ferrous Metals, Second (Experimental) Report to the Atmospheric Corrosion Research Committee, British Non-Ferrous Metals Research Association," Trans. Faraday Society, vol. 23, 1925, pp. 113–185; (*b*) "The Role of the Corrosion Product in the Atmospheric Corrosion of Iron," Trans. Electrochemical Society, vol. 64, 1933, p. 31; (*c*) "A Laboratory Study of the Atmospheric Corrosion of Metals," Trans. Faraday Society, vol. 27, 1931, pp. 255–277.

[7] U. R. Evans and associates, "The Passivity of Metals" (A series of seven papers), Journal of the Chemical Society, London, 1927–1932.

[8] Archeological relics have been unearthed on the site of Dura-Europos on the Euphrates River, by the Yale-French Academy Expedition which indicate that the making of wrought iron on a commercial scale dates back 1800 years from the present time. (*Iron Age*, Jan. 10, 1935, p. 13.) The oldest samples so far discovered originated about 1000 B.C.

few cases corrosion has been arrested by impressing an electric current on the metal, as in the recently developed "cathodic protection" of underground pipe.

The prevention of corrosion of iron and steel in their various commercial forms is often a matter of great importance. The physical properties of these metals can be so well and economically adapted to common requirements that they are well nigh essential to our comfort and civilization. It is, therefore, not surprising that the tonnage in use is nearly twenty times that of all other metals together. Unalloyed iron and steel, unfortunately, have a rather limited ability to protect themselves, except under certain special conditions as in dry air. Nevertheless, these useful metals have in many cases given good service for forty years or more under varying conditions of exposure with little or no artificial protection. Rails and underground pipe lines are typical examples. It is usually desirable, however, to apply paint coatings to the metal when exposed to the atmosphere, if only for the sake of appearance.

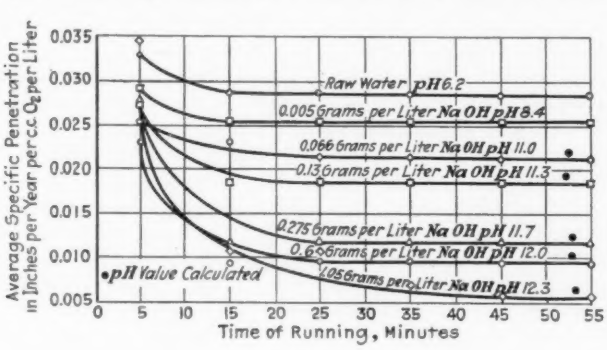


FIG. 1

When metals are "idle" they often show greater depreciation from corrosion than when in continuous service; therefore, deferred renewals or inadequately protected iron and steel, unused during the years of the recent depression, are likely to be quite a factor in restoring normal production.

Stainless steels (steels high in nickel and chromium such as the well-known 18–8) are the best examples of what may be accomplished by applying the first principle of protection already referred to. To secure the best results, the alloying metal should be retained in solid solution in the iron. These alloys exhibit, in some corrosive environments, marked ability to build up a highly resistant surface layer which quickly arrests corrosion.

The second principle of protection is illustrated by the use of neutralizing reagents, passivators, and various means for removing oxygen from water. These expedients have proved useful and economical in controlling corrosion under various conditions in practice. This type of protection cannot be discussed in detail within the scope of this paper, although it depends in principle upon the formation of a resistant layer (solid or liquid) on the metal.

The third type of protection, artificially applied coatings of resistant materials, is the one most generally employed and is therefore discussed in more detail.

FILMS AND COATINGS

In discussing metal-surface protection, it is convenient to consider the subject under three headings, a classification which is based on the thickness of the protecting layer:

(1) Thin films which may be invisible and sometimes only a few molecules in thickness.

(2) Metallic and non-metallic coatings, such as are obtained by galvanizing with zinc or by painting.

(3) Coatings of more substantial thickness, such as reinforced hot-bituminous or portland-cement mixtures.

FILM PROTECTION

Much more is known about the physical properties and the structure of metals than about their surface condition under various exposures, yet it is evident, at least in the case of the metals in common use, that we are dealing with a film-covered surface and not with a real metallic surface. Without the natural tendency to build up surface films that are often self-healing, all but the rarer noble metals, such as gold or platinum, would have a much more limited life under most service conditions. The growth of these very thin invisible films has been demonstrated mainly by their effect in depressing the potential of the metal, while in other cases their presence has been demonstrated by dissolving away the base metal so that the film is rendered visible under the microscope.

Fortunately the film-building properties of steel can be improved to almost any degree desired by alloying this metal with other metals, such as chromium, nickel, and copper, which impart to iron some of their own inherent characteristics in this respect. Chromium, although more oxidizable than iron, is an ideal metal to increase the corrosion resistance of iron, as it forms a solid solution with iron, and, up to about 20 per cent, the alloy is readily forgeable and has good physical properties when properly treated in fabrication. When 12 per cent or more chromium is present in solid solution in iron (i.e., one atom of chromium to eight atoms of iron) an exceptionally strong and adherent film is developed which results in an abrupt improvement in corrosion resistance in certain environments, such as moist atmospheres.[9]

The addition of as little as 0.15 per cent copper increases the resistance of bessemer steel four or five times in industrial or sea-shore atmosphere, and by increasing the copper to 0.4 per cent and adding about 1 per cent chromium with 0.8 per cent silicon and about 0.15 per cent phosphorus, the resistance compared with "copper steel" can be more than doubled in the atmosphere and in salt water, and at the same time the tensile strength is increased by 50 per cent. The addition of 3 to 5 per cent chromium provides another series of ferrous alloys at moderate cost that have very desirable physical properties and considerable resistance to corrosive sulphur compounds and oxidation, and therefore are now much used, as for instance, in oil-refinery equipment.

The well-known stainless steels, of which 18–8 chromium-nickel steel is the most widely used, are the most highly developed of the rust-resisting ferrous alloys, but no one metal has been found nor is likely to be found that will serve all purposes economically.[10]

Protective films can also be formed on ordinary iron that has no inherent power to protect itself by the use of inhibitors, such as soluble chromates or alkalies. The inhibiting power of these substances depends on their ability to react with the metal and form a solid protective film or inhibiting layer of solution on the metal surface. This principle has been applied to the prevention of corrosion from brine in refrigeration, and from recirculating cooling water in condensers, by the addition of

[9] "The Structures of the High Chromium Stainless Steels and Irons," by E. C. Bain, Year Book of the American Iron and Steel Institute, 1930, p. 271.

[10] Duplex metals have been made for some purposes by welding a layer of 18–8 steel (Plykrome) or pure nickel (Ni-clad) about $1/_{32}$ in. thick on a carbon-steel base. Such combinations are readily fabricated into many forms by fusion-welding with the right kind of wire and suitable technique.

sodium chromate and by the well-known alkaline reagents in boiler-water treatment, and is often found to be more economical than the substitution of a more expensive metal or the application of a protective coating.

PROTECTIVE COLLOIDS

Fine particles dispersed in water, such as clay colloids in slightly alkaline solutions, form protective deposits that sometimes greatly retard corrosion. The adsorption of hydroxyl ions on the surface of colloidal particles probably assists by increasing the alkalinity of the solution in contact with the metal.

For example, steel water mains in the Middle West have been found free from corrosion under a layer of absorbed particles of clay about $^1/_{16}$ in. thick. The author has also found this type of protection to be highly important in connection with the use of steel drill pipe. The mud-laden fluid, which circulates through the pipe, is usually conditioned with colloidal material where this is not formed in sufficient quantity in the course of drilling. To stabilize the colloids the fluid is maintained at the proper alkalinity, ranging between a pH of from 8 to 10, according to the nature of the fluid. Fortunately, mud conditioning favorable to good drilling practice has been worked out, but apparently without any thought of preventing corrosion. This practice which affords considerable protection against corrosion, therefore, explains why failures from corrosion fatigue are relatively a rare occurrence in rotary drilling.

OXIDE COATINGS

Oxide coatings, such as the Bower-Barff or the coating formed on iron in a hot phosphate bath by the Parkerizing or Bonderizing processes, or the dense adherent layer of corrosion products that form on aluminum or copper steel in air, like the thinner surface films already discussed, are so firmly attached to the metal as to suggest some kind of atomic bond, the nature of which has not yet been discovered. The adherence of paints and lacquers is materially improved by applying them to surfaces that have been so treated as to form a tight bond between the surface and the coating.

PAINTS AND LACQUERS

About 80 per cent of all iron and steel products require some kind of protection if only for the sake of appearance. For these metals under atmospheric exposure, about 100,000,000 gal of paint are used annually on the average. The quality of these paints has been notably improved in recent years. For uses under atmospheric exposure, paints consist essentially of (*a*) a vehicle, usually linseed oil with a little oxidizing material to accelerate drying; and (*b*) various pigments to improve the strength and weather resistance of the coating. Basic pigments, such as the much-used red lead, and lead or zinc chromate, inhibit corrosion when applied next to the metal, and therefore are commonly used as a priming coat. That this useful property actually exists in pigments has been proved by the fact that when paint films containing 20 per cent or more of these compounds were scratched and the metal exposed, it was found that corrosion had been greatly retarded. It is mainly for this reason that red lead has given such good results in primers. The coating next to the metal should be thin enough to wet the entire surface, including all depressions and cracks. The outer coatings should be made less fluid by the addition of a larger proportion of pigment. For use under atmospheric conditions, the outer coating should be designed mainly to assure durability and the exclusion of water. The addition of two pounds of flake aluminum per gallon of vehicle (preferably spar varnish) has given good service as an outer coat when exposed to weather conditions.

Synthetic resins of the phenol-formaldehyde type are extensively used in the manufacture of enamels and clear varnishes. They are quite resistant to the effect of exposure to water and usually give excellent service. Other synthetic resins, made from the reaction of phthalic anhydride and glycerin, such as the alkyd-type resins, are generally plasticized with fatty acids of oils. These resins, when pigmented, find a wide use in the automotive industry. They can be sprayed or brushed, and produce surfaces of high gloss and of excellent weather resistance. However, their resistance to water is not usually as great as properly formulated varnishes of the phenol-formaldehyde type.

Chlorinated rubber and other somewhat analogous rubber compounds have appeared recently in the paint industry. These compounds produce coatings which are quite resistant to dilute acid and alkali solutions. The unsatisfactory adhesion which such coatings sometimes give when applied to ordinary metal surfaces may be overcome through the use of properly formulated tung-oil compounds as plasticizers.

Lacquers are distinguished from paints in that the lacquer vehicle hardens entirely by evaporation of a volatile constituent and not by oxidation.

In the nitrocellulose-lacquer industry, many advances have been made during the last few years. Hundreds of new plasticizers and solvents have been utilized, and the formulations are extremely varied. As a rule, low-viscosity nitrocellulose is plasticized up to one-half its own weight with such organic plasticizers as dimethyl phthalate, dibutyl phthalate, or tricresyl phosphate. Various grades of natural and synthetic resins are employed to give adhesion and gloss. A very wide range of solvents of low, medium, and high boiling points is utilized to secure the desired speed of evaporation.

Assuming that proper care in application has been taken so as to get a uniform adherent film of the right thickness, the life of painted metal depends upon (*a*) the nature of the metal; (*b*) freedom from foreign matter between the metal and paint, such as hydrated oxides of iron (rust), moisture, and soluble salts; (*c*) the proper selection of suitable vehicles, pigments, thinners, and driers properly blended; and (*d*) the atmosphere. The formulation of paints and lacquers calls for a high degree of technical skill which is readily available in the paint industry. As paint films are slightly pervious to moisture, anything that interferes with perfect adhesion to the metal or that promotes corrosion under the paint will bring about early failure. Hence it is most essential to secure a clean dry surface. The first coat should be applied immediately after the metal is cleaned. The initial film formed in the air may be an oxide which will be subsequently hydrated and thus loosen the bond. In some cases it has been found of advantage to sweep the metal with the flame of a gasoline torch to thoroughly dry the surface just before painting. Such coatings when applied on warm surfaces of newly rolled steel have proved to be highly durable. An outer water-proof coating over an inhibitive base coat is usually quite effective, and two or three coats are naturally much better in this respect than one.

For under-water service the precautions referred to should receive special consideration. Wherever practicable, the paint should be thoroughly dried before immersion, as thereafter there is no chance for further drying by air. It has been found that more artificial drier can be safely used in paints for under-water service than under atmospheric exposure. When the drying time is limited for economic reasons, as, for example, when painting ship hulls in dry dock, quick-drying paints of high durability should be employed.

For the painting of steel hulls for fresh-water service, the following formula has proved satisfactory: Composition of

pigment: red lead 75 per cent; lead chromate 12.5 per cent; zinc chromate 12.5 per cent. Composition of vehicle: treated china-wood oil, 100 per cent (volatile, 63 per cent, non-volatile, 37 per cent).

This mixture dried to the touch in one hour and the hull was immersed 24 hours after the paint was applied to a freshly sandblasted surface. The sandblast cleaning was done at a cost of two cents per square foot. After two years in service this coating seems to be holding tightly to the metal in pit holes caused by previous corrosion. It is interesting to note that serious pitting occurred on the hulls of ore carriers that were laid up for two years during the depression, but no material corrosion was found on the unpainted hulls of these ships prior to that time when they were in regular operation eight months of the year.

Paints when used under water often fail by blistering. This is probably due to absorption of water and to building up of osmotic pressure under the paint films. Evidence of any tendency to blister can be obtained by immersing test panels for a month or two after they have been cleaned and coated in strict accordance with the procedure that will be followed in practice. A relatively impermeable and strong outer coat of a highly durable paint applied over the wrong kind of primer has blistered seriously under water. Pure red lead and some of the rubber derivatives or phenol-formaldehyde resin paints have given the best results in fresh-water immersion tests.

Much more is known about the formulation of paints for atmospheric service than for under-water service. Two coats of different paints, applied with a limited drying time, have a tendency to cause blistering in water, and therefore, single coats have sometimes proved more durable than double coats under these conditions. For submerged service it may prove better to make the priming coat relatively less permeable than the outer coats. Improvements in paints for use under water may be expected as a result of work now in progress.[11]

TESTING OF PAINTS

While there have been many practical tests of paint coatings under atmospheric conditions, much less has been done on paints for use under water or at the water line. It would seem to be highly desirable to have definite specifications for procedure in testing with respect to the important factors that determine the life of the coating in air, in water, and at the water line. Tests should be made under all these conditions to secure the most complete data on the behavior of paint coatings in each environment.

The testing records should include general information as to all chemical and physical characteristics of the paint and the drying time of each coat. Atmospheric conditions should be recorded and should be normal, especially as to humidity, when the paint is applied. The specification should also include detailed instructions as to the composition and finish of the bare steel, the preparation of a clean surface, and method of application of the paint. Laboratory tests should be made to indicate the adhesive properties, the resistance to impact of each coat, and its permeability to water. The time of drying of each coat should be specified, and, where the paint is to be immersed in water, the time between the application of the last coat and immersion of the finished test panels should be specified so that each paint under test will be treated in the same manner. In testing paints for reconditioning ship bottoms or for use in other locations where the drying time is limited, this limitation, of course, should be followed in preparing test panels.

The corrosion-resisting properties of the base metal have been shown to influence the rate of destruction of paint coatings. For instance, paint applied to copper steel in freight-car construction has been shown to last much longer in service than when applied to ordinary steel, and the serviceability of paint might be expected to be still better when more resistant steels are used. Hence, it would seem important to carry on exposure tests with bare and painted metals in the same location and at the same time for, after all, most steel construction is painted, if only for the sake of appearances, and the life of the painted surface is of more practical interest than that of the bare metal.

Petroleum grease, wax mixtures, or similar non-drying compounds, when well rubbed on a clean surface, have given good results in protecting steel exposed to water, as in water ballast tanks on ships or in damp coal mines where the coating is liable to be injured by abrasion. Elastic water-proof paint films of the drying type have been successfully applied on a slushing grease base coat.

COATINGS FOR PIPE UNDERGROUND

The principal object of a protective coating on pipe is to reduce maintenance costs as far as possible. This is particularly important when the pipe is laid underground and where the coating cannot be easily renewed. The efficiency of a coating will depend on the life of the coated pipe as compared with bare pipe. This in turn depends upon the thickness and character of the coating and the physical and chemical properties and variation in water content of the soil. The question, "What is the best coating for use underground?" is therefore largely an economic one.

The American Petroleum Institute and the American Gas Association have placed research associates at the Bureau of Standards. This cooperative association has conducted two independent tests. The first, sponsored by the American Petroleum Institute, includes 46 coatings on short sections of pipe and 19 coatings on operating lines. The American Gas Association has sponsored a series of tests including 42 kinds of proprietary coatings applied to 2-ft lengths of 2-in. pipe. These coatings were tested in typical soils, the corrosive character of which had been previously tested by exposure of bare metal for several years.[12]

RESULTS OF BUREAU OF STANDARDS' TESTS

The facts so far established as a result of the Bureau of Standards' tests on coatings and bare metals are:

(1) The chief causes of coating failures arise from injuries to the coating before the pipe is laid in place, from distortion by soil stress, and from deterioration of the coating material.

(2) Very few of the present commercial coatings are entirely adequate to prevent underground corrosion under all soil conditions.

(3) None of the commercial coatings are proof against electrolysis, although many of them offer additional resistance.

(4) The relative behavior of coatings is different in different types of soils.

(5) All coatings fail to protect in some corrosive soils, but by making a judicious selection corrosion may be greatly reduced. Therefore, it pays in many cases to lay the pipe bare or to apply only a thin and imperfect coating of low cost over

[11] Information regarding paints for special purposes may be obtained in circulars of Scientific Section of the Institute of Paint and Varnish Research, Washington, D. C. See circular no. 331, June, 1928.

[12] Bureau of Standards Research Papers Nos. 95, 329, 359, and 638; and Technical Paper No. 368.

the whole line, rather than a more costly one, with the expectation of reconditioning the line after failures occur.

(6) Paints or single-dip bituminous coatings are of very little use for underground protection, except that they may limit the area under attack.

(7) Reinforced or shielded fabrics improve bituminous coatings, but the thickness of the coating should be not less than 0.125 in. in corrosive soils.

(8) Organic fabrics tend to rot in certain types of moist soil containing certain kinds of bacteria. Saturated asbestos felt has proved satisfactory under these conditions.

(9) Coal-tar pitch has sometimes been found more durable and less permeable to water than petroleum asphalt.

(10) Hot-galvanized zinc coatings afford considerable protection in some soils, their value depending upon the thickness of the zinc and the character of the soil.

(11) Cathodic protection of a pipe line that has been given a bituminous coating of high electrical resistance has afforded complete protection at moderate cost in limited soil areas having relatively high conductivity.

(12) With respect to the bare metal, soils vary considerably in their corrosivity. In many soils the action between the metal and the soil is not severe. No material difference in corrosion penetration is found between the various commonly used types of ferrous metals in any of the corrosive soils, although in the more corrosive, the rate of penetration varies greatly with the character of the soil. As indicated in Fig. 2, the rate of penetration of the metal in the many types of soil usually decreases with time, rapidly at first and then more slowly.

As a result of the work centered at the National Bureau of Standards from thousands of test pieces that have now been exposed for ten years in many different types of soil, considerable progress has been made in the study of soil factors and in correlating these factors with the degree of corrosion. At present, however, it is impossible to determine with certainty the economic justification of any type of coating practice. In other words, coating practice is not yet on a strictly scientific basis. However, if this work continues (and it would be a distinct loss if it should now be dropped) it will quite likely become possible to make a reliable estimate of the value of certain coatings after an examination of the soil and the locality in which the pipe is to be laid.

ESSENTIAL REQUIREMENTS OF UNDERGROUND COATINGS

The most essential requirements of coatings for use underground are:

(1) Material used must not be attacked by solutions in soil.

(2) It must permanently prevent contact between the soil and the pipe and exclude water, or a protective layer of inhibitive solution must be maintained between the soil and the metal. As bare pipe nearly always fails by pitting in corrosive soils, the object should be to eliminate as far as possible differences of potential on the surface of the metal, since these are the main causes of local corrosion. As these variations in potential are due mainly to variations in the soil, contact between the soil and the metal should be prevented at all points. The soil water itself is not usually very corrosive, except where local variations in concentration of dissolved substances occur.

(3) In the case of bituminous coatings, the layer next to the metal should adhere well to the metal and be made relatively soft so as to resist cracking, but the outer layer should be hard enough to resist soil stress. Distortion by soil stress is the main cause of the destruction of bituminous coatings and should be prevented by interposing a rigid and durable shield between the coating and the soil where the coating material is not sufficiently rigid in itself to prevent this action. A thin stiff rolled-steel sheet formed to the shape of the pipe in semi-circular sections and well coated, or a spiral wrapping of celluloid seems to serve fairly well for this purpose. Where the steel sheathing corrodes it reduces the corrosive matter in the adjacent soil. A single coat of vitreous enamel on each side of a thin steel sheet has been suggested by the author for this purpose, as it seems to have most of the essential requirements, provided it can be manufactured at reasonable cost.

Bituminous coatings that are intended to be in any sense permanent for protection of pipe against corrosive soils, should be reinforced with an inert filler or a durable fabric with a total thickness of at least $^1/_8$ in.

The coatings already available for corrosive soils that meet these requirements are the reinforced or shielded bituminous coatings over $^1/_8$ in. thick; asphalt mastic, containing a high percentage of inert mineral material, over $^3/_{16}$ in. thick; stiff petroleum-grease mixtures reinforced with fabric; and dense portland-cement concrete at least $^3/_8$ in. thick.

The inside of water mains of all sizes can now be effectively protected from corrosion and tuberculation and resulting reduction in flow by the application of bitumens containing a filler, or portland-cement mixtures. These materials are applied centrifugally, the former to a minimum thickness of $^1/_{16}$ in. and

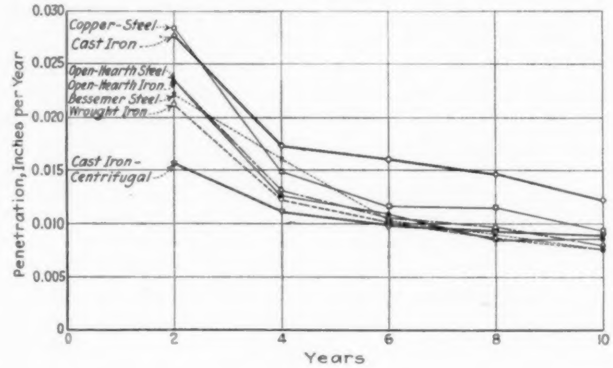


FIG. 2

the latter to $^1/_8$ in. or more. Cement-lined steel pipe is now available on the market in sizes $^3/_4$ in. to 30 in., inclusive.

CONCLUSIONS

Prevention of corrosion is an economic problem, the practical solution of which requires the cooperation and best judgment of chemists and engineers, with full knowledge of all the factors, especially those that control the reaction in each particular case.

A fundamental study of metal surface reactions and of the bond existing between metals and films, and various means for forming these and other protective layers (solid or liquid), should assist future improvements in protection of metals from deterioration. Practical means of prevention of corrosion have been worked out in most cases, and the selection of the best method has now become largely a question of economics. The use of a great excess in thickness of metal is usually wasteful and particularly objectionable where saving in weight is desirable. Rust-resisting steels often give the answer; frequently it is a matter of controlling the environment by elimination of the cause; but in most cases the solution of this world-wide problem is found in the proper application or building-up of an adequate protective layer on the metal.

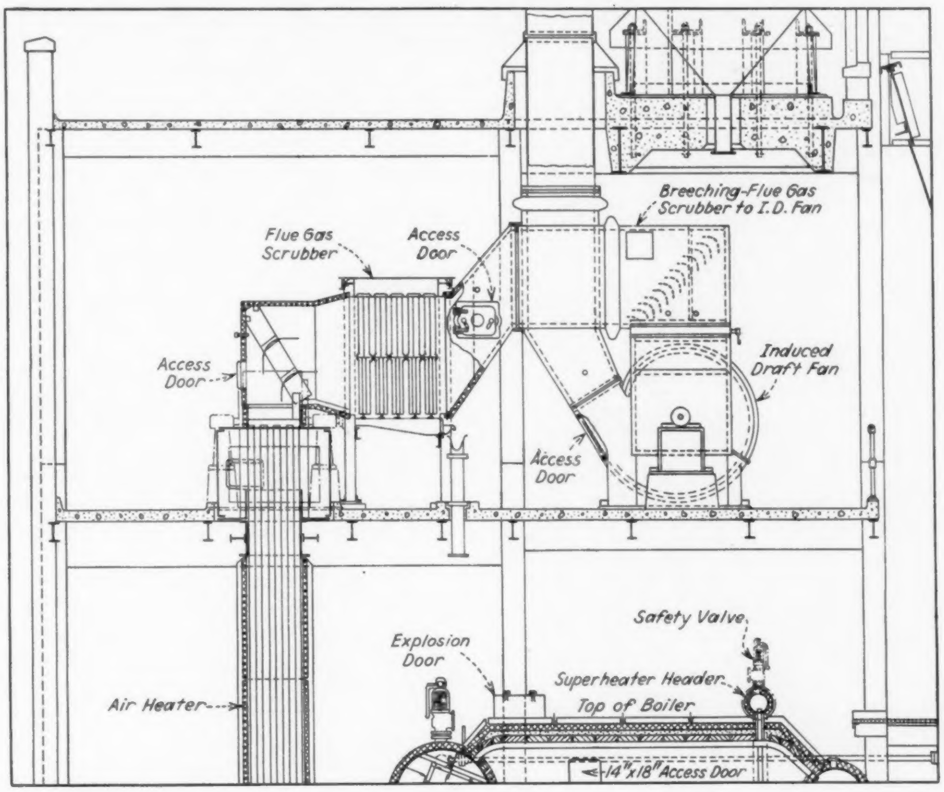


FIG. 1 LOCATION OF FLUE-GAS SCRUBBER WITH RESPECT TO BOILER, AIR PREHEATER, AND INDUCED-DRAFT FAN, PASSAIC PLANT, FORSTMANN WOOLEN CO.

FLUE-GAS SCRUBBERS

Operating Experiences in the Plants of the Forstmann Woolen Company

By F. L. BRADLEY

FORSTMANN WOOLEN COMPANY, PASSAIC, N. J.

THE FLUE-GAS scrubber installed in the plants of the Forstmann Woolen Company is based on the principle of trapping dust particles in a film of water which runs over a series of baffle plates suspended vertically in the gas stream. It is essentially a box installed in a horizontal flue and provided with openings on the front and rear to permit passages of gases through it. A shallow water tank closes the top of the scrubber and serves to support the baffles. The bottom of the scrubber is a rectangular basin that collects the water and entrained dust prior to their discharge to waste. The entire unit is erected on a structural-steel support. (See Fig. 1.)

The operation of the unit is simple and requires little attention. The water level in the supply tank is controlled by a float-operated valve. Water is admitted to the scrubber chamber and distributed to the entire surface of each baffle by orifices located in the bottom of the water tank. The baffles are of ribbed construction to permit the spread of water over the entire surface. The flue gases entering the unit pass over five sets of baffles, so arranged as to permit ample contact of the gas with the wetted baffle surface. The wetted dust and the water are collected in the bottom and discharged to waste through water-sealed discharge nozzles. (See Figs. 2 and 3.)

The scrubber construction is simple. It is made of materials designed to resist the corrosive action of acids and the erosive action of the fly ash. The first baffles were made of cast iron coated with an acid-resisting enamel. Several other metals, including Everdur and special alloys called Ni-Resist and Riloy, have been tested. The housing is made of cast iron lined with chemical tile set in acid-resisting cement. The water tank and basin are also made of cast iron painted with acid-resisting paint.

The units have performed satisfactorily in that they have effectively prevented dust nuisance from the stacks. The scrubber units in both of the company's plants have performed with approximately the same degree of efficiency. A series of tests run on these units showed a dust-removal efficiency of 90 per cent at a boiler load of 60,000 lb, 86 per cent at 45,000 lb and 75 per cent at 30,000 lb. These tests were conducted in the

From a paper presented at a meeting, March 27, 1935, of the Metropolitan Section of The American Society of Mechanical Engineers.

FIG. 2 TEST MODEL OF FLUE-GAS SCRUBBER

Passaic plant on a unit designed to operate on a normal maximum of 60,000 lb of steam per hour. The efficiency of the unit increases as the gas loading increases and it is expected that the efficiency would exceed 90 per cent at loadings greater than 60,000 lb of steam per hour.

During these tests the dust loading per 1000 cu ft of gas reduced to a 70 F temperature basis was found to be approximately 240, 212, and 103 grams, respectively, for the boiler loads noted. The dust loading per 1000 cu ft of 70 F gas leaving the scrubbers was found to be 22, 36.8, and 26.2 grams, respectively, for these same loads. Screen analyses of fly-ash samples are given in Table 1.

TABLE 1

Boiler rating lb per, hr	——Percentages passing through screen——			
	325-mesh 43 micron	200-mesh 74 micron	100-mesh 140 micron	50-mesh 280 micron
45,000	48.8	75	95.5	99.9
30,000	71	89	98.3	100

Screen analyses of the particles in the outlet gas at loads of 45,000 and 30,000 lb per hr showed 99.9 per cent passing a 325-mesh screen, and 100 per cent through 200-mesh and 100-mesh screens.

The draft loss through the unit is moderate, amounting to 0.6, 0.31, and 0.15 in. of water at 60,000, 45,000, and 30,000 lb steam load, respectively. The gas temperature drop through the scrubber was found to be 172 F, 160 F, and 168 F, respectively, at these boiler loads. Analysis of the gas entering and gas leaving the scrubber shows a reduction of approximately 10 per cent of sulphur gases and a negligible percentage of CO_2. The average velocity of the dust particles was found to be 1870 and 1242 ft per min at loads of 45,000 and 30,000 lb per hr, respectively.

The Garfield plant units which handle an approximate maximum of 2050 lb of gas per minute require a supply of approximately 100 gpm of wash water. The units in the Passaic plant which handle a maximum of 1780 lb of gas per minute require a supply of approximately 70 gpm of wash water. The temperature of this water entering the scrubbers varies normally between 50 and 80 F for winter and summer conditions, while the water leaving the scrubber varies in temperature from between 90 to 120 F under the same conditions.

Tests on the Passaic units show that dust per gallon of waste water is approximately 0.145, 0.088, and 0.026 lb for 60,000, 45,000, and 30,000 lb steam load, respectively. The average results of a number of tests indicate that the waste water contains approximately 0.016 per cent of sulphuric acid, 0.02 per cent of sulphurous acid, and a small amount of undissolved SO_2 and CO_2 entrained in the water.

One of the first problems encountered in the operation of these units was a collection of dust at the entrance to the scrubber itself. The gas flowing from the air preheater to the scrubber changes its course at the bottom of the scrubber by an angle greater than 90 deg. This change of direction, together with a reduction in velocity, caused some of the fly ash to drop out of the gas and collect at the entrance. This deposit, moistened by a small but troublesome amount of water splashing from the baffles, grew in a few days to such proportions that the moisture, by capillary attraction in the dust deposit, soon reached several tubes of the preheater. This started a slight corrosion which, if it had not been caught at its inception, would have caused considerable trouble.

A steel-plate baffle approximately 18 in. high was installed at the bottom of the scrubber inlet duct approximately 2 ft 6 in. in from the first row of baffles. The scrubber side of this baffle and the sides and bottom of the inlet duct were protected from corrosion by chemical tile. A series of sluicing nozzles operated at a water pressure of 125 lb during daily ash-sluicing periods has proved an effective means of preventing subsequent accumulations of dust.

A less troublesome deposit of soot and damp ash on the bottom plate of the scrubber outlet duct was also as effectively eliminated in a somewhat similar manner.

The cast-iron drain trough and the waste-collection basin stand effectively considerable abuse from the erosive and corrosive effects of the discharge water. The surfaces are protected by a coat of Nitrose which is renewed periodically.

The baffles are the most vulnerable parts of the scrubber. They are subject to the erosive effect of the fly ash as well as the corrosive effects of the acid solutions formed in the scrubber. The initial cast-iron baffles painted with special acid-resisting baked enamel lasted, on an average, approximately 1000 boiler operating hours, during which time 1180 tons of coal containing 7.5 per cent of ash and 1.75 per cent of sulphur were burned. The cast-iron baffles were replaced with Ni-Resist baffles, a nickel-cast-iron alloy. These plates were recently inspected after approximately 4000 hr of operation, during which time approximately 1642 tons of coal containing 7.5 per cent of ash and 1.75 per cent of sulphur were burned. While these plates show some wear, the effects are not alarming.

A number of test materials have been tried out in both our plants. The average penetrations per 1000 hr, based on tests are recorded in Table 2.

Another material called Elslip, consisting of vulcanized rubber, asbestos, and graphite, is being tried out. Definite results have not, as yet, been determined.

The problem of securing a suitable material for the scrubber

drain piping was given much thought. Chemical tile, lead-lined pipe, cast-iron pipe, and ebony-impregnated transite were considered. Transite class "A" pipe and fittings with Dresser couplings were installed. While the sale of this material for scrubber-drain service was made by the manufacturer on an experimental basis only, the material stood up very well, ex-

TABLE 2

Material	Penetration, in.	Duration, hr	Coal burned, tons
Ni-Resist...........	0.00685	2393	1642
Bare gray iron.......	0.0302	1274	964
Riloy...............	0.0085	1274	1642
Everdur.............	0.00508	3018	2000

cepting in the case of the fittings which gave some trouble, due to circumferential expansion. After approximately six months of operation, the original piping and fittings were replaced by ebony-impregnated transite class "C" pipe coated internally with asphalt with a high melting point. The installation has been in operation about 11,640 hr, during which time 14,891 tons of coal have been burned. The material is performing without signs of deterioration.

Yellow pine has been found to be a satisfactory material for handling the scrubber drains without appreciable deterioration.

Stacks, especially steel stacks, are vulnerable to attack where stack-gas temperatures are low enough to permit condensation. With an expected maximum temperature drop in flue gas of 100 F, it was decided to hold in abeyance any definite action in regard to insulation or lining the stacks. The actual temperature drop proved to be approximately twice that expected. During very cold spells in the winter, condensation has occurred in sufficient amounts to make it unwise to depend on an acid-resisting paint for protection. Therefore magnesia-block insulation was installed and covered with a hard-finished refractory cement and waterproof coating. This remedy has proved effective in eliminating condensation and corrosion. A recent inspection of the stacks has shown that the hard finish on the insulation is in satisfactory condition and free from cracks.

Among the advantages to be listed in favor of these scrubbers should be included efficiency of dust removal; removal of obnoxious gases; and the protection of the induced-draft fans

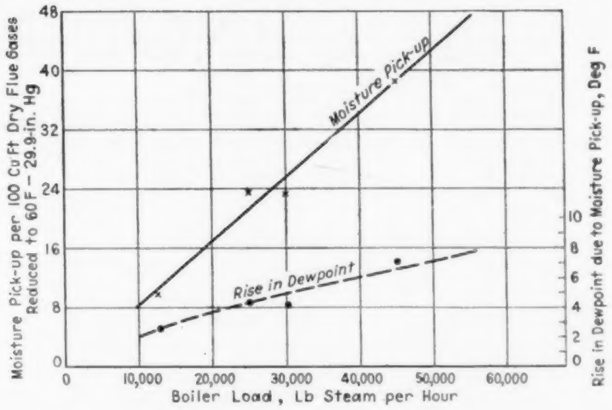


FIG. 4 MOISTURE PICK-UP AND RISE IN DEWPOINT OF FLUE GASES PASSING THROUGH SCRUBBER, PASSAIC PLANT, FORSTMANN WOOLEN CO.

and duct work. As stated previously, the elimination of fly ash by the scrubbers has been effective. The tests show that the fly ash passing through the scrubber and passing through the stacks is not greater than 43 microns in size. It is generally agreed that particles smaller than 20 microns cannot be classified as dust. They belong to the category of cloud or fume particles. Such particles settle very slowly, and even in still air they may remain in suspension almost indefinitely. Our tests show that by a comparison of the gas dust loadings in and out of the scrubber the dust removal is in the order of 75 to 90 per cent. Therefore, if it is agreed that approximately 50 per cent of the dust in the average flue gas is 20 microns or less, our scrubbers are removing particles that fall outside the category of dust. Therefore, the results obtained appear to have attained the objective desired by the designers.

As noted in the figures previously stated, the removal of obnoxious gases from the gas discharge has also been an important item. This is especially important in plants located in congested districts or in cities where ordinances covering these nuisances are enforced.

During the initial installation the induced-draft fans were painted throughout, except for the shaft, with Nitrose paint. This step was taken as precaution against a possible carry-over of water particles and the consequent corrosion which would result. The fans have been inspected at frequent intervals in order to catch any corrosive action in its initial stage. On a recent inspection after approximately 27 months of station operation, the first evidences of wear on the painted surfaces have been observed. Although the paint is still in good condition and provides satisfactory protection for the metal, we have considered it wise to repaint these units with Nitrose paint.

It is believed that the scrubber units have been reasonably free from moisture carry-over into the induced-draft fan equipment. However, tests were conducted recently to determine the moisture pick-up and its effect on the dewpoint of the gases leaving the scrubber. The test curves of Fig. 4 show that the relation between boiler load and the corresponding moisture pick-up is a straight-line relation, and that the rise in dewpoint in this type of scrubber is very moderate.

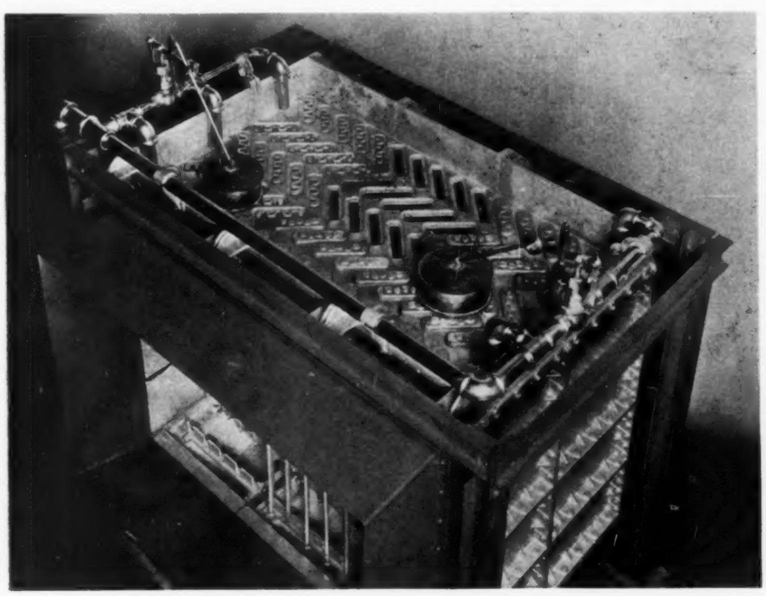


FIG. 3 TEST MODEL OF FLUE-GAS SCRUBBER

THE ENGINEER'S ENGLISH

Fifth Address of a Series Before the Engineers Club of Baltimore

BY JOHN C. FRENCH

THE JOHNS HOPKINS UNIVERSITY

SOME weeks ago I saw a lecture announcement the title of which interested me greatly. It read something like this: "Welding, the Engineer's Latest Tool;" and it suggested inevitably the thought that the story of the engineer's tools would be the history of his profession. Indeed, it would not come far short of a history of civilization, for what primarily set man apart from other animals was his mastery of the art of making and using tools. As our conquests of time and space continue, we look to the engineers to invent new and increasingly complex instruments of precision and to instruct us in the use of them; and the wonders of these modern devices quite eclipse for us the significance of the primitive tools created by your predecessors milleniums ago. For example, the teletype quietly and efficiently lettering on a tape at one end of a thousand-mile wire the words that a typist's nimble fingers are writing at the other end is to me an awe-inspiring machine, and I make no pretense at understanding how it works; but a moment's reflection reminds me that it is not half so wonderful as that commonplace miracle of intelligible speech which gives us the message itself.

WRITTEN SPEECH IS A TOOL OF PRECISION

In this contrast I find the real significance of the subject on which I am to talk to you, for I am asked to discuss what might be called the engineer's oldest tool. Written speech is also an instrument of precision, perhaps the greatest of all such instruments yet devised by man, a prerequisite to all real progress in civilization, and the first essential in the creation of a profession. I should be glad if I could say that engineers, who so excel the rest of us in the comprehension of all manner of mechanical devices, were also notable for their readiness and skill in the use of language; but such is not my observation. Unfortunately, the mastery of a science does not carry with it high skill in the art which corresponds to the science. The professor of ballistics is not necessarily the expert marksman. Some years ago when I spent much of my time reading the themes and essays of college students and conferring with them about their written English, I found that the bookish lad who couldn't drive a nail commonly wrote better papers than the equally intelligent student who loved to do things with his hands and cared more for practical matters than for ideas.

The reason is not hard to find, for in the practice of an art, aptitude and taste play a leading rôle and skill comes only as a result of a painstaking discipline which one is reluctant to endure when his interests pull strongly in another direction. Indeed, taste and aptitude do not always move in the same direction. I have known persons who sought earnestly and laboriously for literary excellence when it was manifestly impossible for them ever to attain it. What they hopelessly strove for was distinction in a fine art—a thing that notoriously depends upon the favor of nature; but we are concerned at this time with something quite different, the practical art of everyday writing, an essential part of every man's equipment no matter what his profession and a tool for which any real participation in the world's affairs creates a constant need.

The significance of this practical art of written speech is twofold, for it is at the same time a general or communal tool and a purely individual acquisition. Its importance as a community interest may easily be overlooked. For some years we have been suffering from the effects of what used to be called hard times; and our philosophers, great and small, have been very busy trying to tell us just what has caused our troubles and what we must do to end them. It must be admitted, I think, that the economic doctors have not been brilliantly successful, either in diagnosis or in treatment; and our liveliest hope is that the patient will presently get well of himself in spite of their efforts. But some of their suggestions are interesting. One of these is that we are suffering from an era of machines. Our implements of agriculture, manufacture, and transportation are too efficient; if we could but go back to the simpler ways of a more primitive society all, they tell us, would be well.

Those who attribute hard times to the perfection of mechanical inventions overlook the fact that periods of depression were not unknown in more primitive days; and they forget, too that machines that lessen manual labor are not the only instruments with which we build a civilization. There are social mechanisms which mean even more to our comfort and happiness. The devices by which we contrive to live together and exercise a common will are of tremendous importance; and it is only too apparent that these social mechanisms have lagged in efficiency far behind the machines that feed and transport us. We overcome the pull of gravitation and the resistance of air and water far more successfully than we conquer the deadly inertia of stupidity and greed. Why? Isn't it largely because we do not adequately understand each other? The right ideas are not found and made to prevail because we have not sufficiently improved and mastered the instruments which are concerned both with the formation and with the communication of ideas. Lincoln's Gettysburg Address has become an enduring classic because it phrased with ultimate clarity the ideas which anybody can recognize as appropriate for the occasion. I like to believe that whenever the truth is thus compellingly expressed the majority in any human society will accept it.

CLEARNESS A PRIMARY QUALITY OF WRITTEN SPEECH

If this is true, and I am convinced that it is, it would be hard to overstate the importance to all of us of clearness in the use of langauge, for clearness is the primary quality of spoken and written speech. All the other qualities may be summed up under the word interest, meaning whatever lays hold on attention and feeling; and important as these qualities are they must depend for any real effectiveness on that purely intellectual appeal that results in understanding. Lucidity of expression is not only essential for the communication of thought; it is essential to thought itself. We can have vague but powerful emotion without any embodiment in words;

but to get an exact idea into being we must be able to express it for ourselves, to call into existence a form of words in which the idea may take on a living shape.

I am well aware that there are persons who seem abundantly supplied with words, but whose ideas, though fluently expressed, do not command our confidence. The radio is eloquent with their sophistries and great masses of unthinking listeners are swayed by them. Doesn't that mean that all we need is more and better ideas, not more clearness in their expression? I think not. If you will examine coldly the speeches of our radio demagogues, particularly if you will read them carefully in print, you will find, I think, that their English though glib, is not really clear but is as shallow as the thought; and you will be more than ever convinced that they are not real leaders. If it is true that they cannot speak any more clearly than they think, it is also true that they cannot think any more clearly than they can speak, for thought and language are complementary.

What we need to do, therefore, is not to scrap the mechanical tools which we have already devised, but to improve our mastery of this tool by which we learn to use them wisely. The recently invented mechanical cotton picker will have far-reaching effects, some of them disturbing; for temporarily, at least, it will deprive many humble workers of employment. Yet in the long run it will benefit all of us, for we shall be compelled by it to improve our social mechanisms and to make our society more efficient as a means whereby human creatures can live together. It will be far better for us to invent a society that will provide a place for the dispossessed share-cropper than to ban the invention that turns him out of his present place in our economic system. This should not imply that I am an enthusiastic New Dealer, eager to seize upon our present discomforts as an excuse to turn our social order upside down. I fear I am not a New Dealer at all, for I am convinced that social change must come gradually, if it is to endure; and I should prefer to see the old machines improved rather than to throw them on the junk pile and entrust our happiness to new and untried contrivances.

IMPROVEMENTS IN LANGUAGE COME SLOWLY

We cannot by immediate mass effort greatly improve our racial possession of English speech any more than we can by act of Congress raise at one stroke the level of the public honesty or the public health. Such ends are accomplished by the slow and steady improvement of the character or physical welfare of individual citizens. A few years ago I had some share in just such a deliberate attempt when a considerable body of scholars, with the help of Andrew Carnegie's money and Theodore Roosevelt's enthusiasm, tried to make radical improvements in English spelling. The reform was much needed, for our spelling is the worst known to the civilized world and the benefits of reforming it ought to be obvious to the most obtuse among us. But did we succeed? We did not. The habit of spelling *through* and *debt* was so ingrained in our practical men that the idea of changing to *thru* and *det*, though quite reasonable to scholars, was intensely objectionable to most adults. The movement failed, as movements to change the calendar fail. That does not mean that there can never be improvement in our spelling but merely that improvement must be gradual; and such gradual improvement is in fact going on. You all probably accept without realizing it the change from *programme* to program and from *omelette* to omelet; other similar changes are taking place.

Thus far I have insisted on the racial and national significance of clear expression as the tool of a complex society, and I have conceded the hopelessness of any sudden or mass improvement in our capacity to use this social instrument. It is obvious that such improvement comes, if at all, slowly and by individual effort. That those individual members of society who labor to possess a good command of their mother tongue are likely to enjoy material advantages as well as considerable personal satisfaction from the accomplishment is a point that need not be labored. Our next question is how such individual improvement can be brought about.

HOW CAN THE ENGINEER IMPROVE HIS ENGLISH?

To make the problem concrete and to keep it within bounds, let us suppose that a technically trained man with his formal education largely behind him is dissatisfied with his power to express ideas clearly. What can he do about it? His task is not easy. If it is hard for somebody else to teach an old dog new tricks, how much more difficult for the old dog to teach himself! He must combine self-criticism with self-instruction. Let me express my counsel to such a man in the following precepts:

(1) Let him review his English grammar:

On this point please don't misunderstand me. I am far from saying that one cannot write and write well without studying formal grammar. There is an art of grammar that can be learned imitatively and instinctively by trial and error, and there is a science of grammar that is studied systematically by rules and examples. Everybody who can read and write has a certain mastery of the art; but not everybody has retained a clear grasp upon his youthful instruction in the science. Rule-of-thumb knowledge may be adequate for the use of a tool; when it is a question of repairing or improving the tool, exact knowledge is better.

I am not proposing a review of grammar as a means of avoiding crass errors in inflection. Such blunders are not usually obscure; they defeat clearness by calling attention to themselves. When a cartoonist in the *Baltimore Sun* makes Winnie Winkle say, "There go two people whom I believe are secretly married," he merely distracts our attention from his clever drawings to his elementary mistake. The science of grammar means far more to us than literal correctness. It underlies that swift analysis of the relations of words which we exercise in both reading and writing. If it is worth while to read well, to grasp with easy and insistent comprehension the text of contracts or reports, it is worth while to have more than a haphazard knowledge of English syntax.

The effect of following a vague feeling for the relation of words is easily illustrated. A teacher of English in Kenyon College has recorded two howlers furnished by his students. One of them, asked to define inertia wrote, "Inertia is the force that keeps a body moving after it has stopped." A keener sense for the reference of pronouns would have been helpful there. Another wrote, "The birds filled the treetops with their morning song, making the air moist, cool, and pleasant." Probably his mind was on his next date, but we can follow his psychology. The words *morning* and *song* carried over into the next phrase in a shadowy way and the writer, intent on saying something rather pretty, did not trouble about syntactical relations. These are but overt illustrations of that muddiness of expression that used to evoke from President Ames, when he was a teacher of physics, the caustic criticism, "Your words mean nothing to me!"

(2) Let him scrutinize his own sentences:

Sentences are the working units of style. An author thinks his way through a subject by paragraphs and writes his way through it by sentences. His inevitable tendency is to make his sentence-forms habitual, just as he does his characteristic stride when he walks without thinking about walking. Here

then, is a good place for our dissatisfied writer to look for bad habits of expression. It will be a useful exercise in self-criticism for him to read a piece of his own writing as if it had been written one sentence to the page. Perhaps he will find that he uses a great many ***and*** and ***but*** coordinations, writing what college instructors call "baby sentences;" perhaps he often permits the lazy trailing as-clause to carry over from speech; perhaps he will discover that he makes little use of those parallel constructions that permit one to pack a great deal of thought into a small compass and drive it straight as an arrow in one direction. It will not be difficult to check his own sentence-structure against that of two or three writers whose work seems to him excellent or, having detected his own deficiencies, to set about to remedy them.

Perhaps I should here guard against the assumption that I am suggesting that our critic of himself should be constantly thinking about his sentence-structure as he writes. The sentence is a unit of execution and is ordinarily best written spontaneously without careful forethought. But it is the ideal unit of revision, for sentences are remarkably malleable. They can be recast in half a dozen different shapes until the expression and the thought are in agreement, and rigid revision into new and better forms will tend to make such forms habitual. An advertising display writer extolling a soap achieved this sentence: "Washed every day when they are taken off the life of a silk stocking is easily doubled." His effort has one merit, emphasis at the beginning and the end; but unfortunately its grammatical back is broken in the middle. The cruelty was quite unnecessary. There are several effective ways of expressing his idea without any such dislocation.

(3) Let him cultivate an ear for words:

Words supply the texture of speech. When we read a book or listen to a speaker we accept his words passively, often divining from the context the meaning of an unfamiliar term and sometimes content with a rather shadowy sense of the current of his thought. But when we sit down to write, words must come as summoned and the first to respond is not always the best suited to express the idea. A keen ear for words is dissatisfied with any but the best; a dull ear, such as Mark Twain declared Fenimore Cooper had, often accepts and uses the first recruit though it is only approximately fitted for the duty. A clergyman preaching a sermon on the life of David mentioned an episode which he called the "assassination" of Goliath. Perhaps that was the first word that occurred to him, perhaps it was the most pretentious and mouth filling; but it wasn't the right word, for Goliath was slain in a fair fight. He was certainly not assassinated or murdered. A half-dozen words might have been in the squad that reported for duty and a careful writer, noting that he had to do with an archaic event would have chosen a word with an archaic suggestion, and would have spoken of the slaying of Goliath.

Those who have heard the late Dr. Welch speaking impromptu, as he did habitually, will remember how he used to hesitate for a word until he had exactly the right one. The process reminded one of a cat daintily picking her way across a wet street. Now such an exacting taste in one's words is possible only for the writer who has and uses a fairly large vocabulary and a large vocabulary is possible only to those who read widely. In this fact you will find the secret of much poor writing. I achieved considerable newspaper notoriety some years ago by telling a reporter who had come to interview me that 98 per cent of the words used in the everyday correspondence of the everyday business man would be included in a vocabulary of 400 terms. The statement aroused much controversy but I still stand by it. A scholar who listed all the words in 2000 business letters found that only about 2000 different words were used in them and that one-half of the actual words, counting every occurrence of every word, as we count the number of words in a manuscript, were comprised in a list of 43 terms, such as *I*, ***and***, ***the***, ***a*** and the like. Now I am willing to admit that ordinary commercial transactions can be dealt with clearly with a surprisingly small vocabulary, if one uses it skilfully; but for the kind of writing that our technical man may wish to do, an adequate vocabulary, got by reading and tested by ready recourse to a good dictionary, is fundamental.

(4) Finally, let him cultivate an eye for things:

Words are potent and significant in themselves. They are possessions of immense value to us. Yet, after all, they are but the symbols which shadow forth other realities, and as symbols they have their inevitable limitations. What a word literally means we call its denotation. All precision and clearness in the use of a word begin with the assumption that the writer knows just what this denotation is. But clearness does not stop there. We do not possess enough words to express denotatively all the meanings that throng into our minds and we cannot keep the words that we do possess focused exactly on the denotations that we want them to express.

Fortunately, words have another function which rhetoricians call connotation, their power to suggest other than their literal meanings. I am speaking, of course, of idea words and not of those few but much-used drudges of the vocabulary that merely express relations between other words. In the successful use of idea words there is always room for the imagination, which, of course, is what I mean by an "eye for things." Indeed, in the highest sense clearness in expression is impossible without imagination. Words bow to the man who sees and knows. They come thronging to those whose observation is so keen and whose senses are so alert that they see images and not vague abstractions, for it is by such persons that words are needed. It would be a great mistake for our technical man to assume that all the color and concreteness of style, all the images and analogies must be left to the poets and the novelists because the plain man expounding plain matters can do without them. He cannot do without them, for all his words are, as Emerson says, the signs of natural facts; and their native core of imagery is always coming to the surface. "The great heart, the clear, deep-seeing eye," says Carlyle, "no man whatever, in what province soever, can prosper at all without these."

AN EXAMPLE FROM HUXLEY

All of the illustrations that I have quoted have, I believe, been examples of faulty English. Let me, then, conclude with a single sentence from Huxley, which I offer as proof of this last point. Note, if you please, how this "clear, deep-seeing eye" brings images thronging to the illumination of an idea which most of us would have regarded as belonging to the realm of purely literal speech.

"That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear cold, logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of Nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of Nature or of art, to hate all vileness, and to respect others as himself."

Slag Tapping of
FLAT-BOTTOM BOILER FURNACES

By J. H. STRASSBURGER

WEIRTON STEEL COMPANY

ASH is being tapped from six pulverized-coal-fired boilers at the Weirton, West Virginia, plant of the Weirton Steel Company. These boilers are part of a group of eight 900-hp, four-drum, three-pass boilers that were installed in 1926 for blast-furnace-gas firing. Blast-furnace gas is fired from the rear under the mud drum into the combustion chamber. Steam is generated at a pressure of 231 lb per sq in. and is superheated to 525 F. Radiant-tube superheaters are located in the front wall of the furnace directly opposite the gas burners. All walls were originally of solid firebrick; the top furnace arch was the only water-cooled surface. The furnace bottoms were constructed of firebrick, laid on concrete, and no basement or ash-handling system was required for the original gas-fired installation.

In 1930 some of the available blast-furnace gas supply was diverted to the coke plant for underfiring two batteries of coke ovens, and three boilers were changed to pulverized-coal firing to balance out the reduction of blast-furnace gas for the boiler house. The coal burners were located in the front wall of the boilers opposite the gas burners. A unit pulverizer, with a capacity of 8500 lb of coal per hr, was installed on each of the three boilers. Approximately one year later, water walls were installed in the side walls in order to reduce the maintenance cost of the solid firebrick walls which were severely punished from the coal firing. The water walls are of bare-tube construction with 25 rows of $3^1/_4$-in. tubes spaced 6 in. center to center. The headers are placed on 18-ft centers. Each wall has a projected area of 243 sq ft.

The results from the water-wall installation were very satisfactory with ratings increased from 175 to 220 per cent. During this period of operation the ash from the coal firing was removed periodically with shutdowns occurring at 30 to 40-day intervals.

The ash was handled manually and five to six days were required with eight men working three shifts to clean up a firebox for another period of operation. While operating the boilers at a higher rating than normal, the boiler-house superintendent discovered that one boiler contained a molten mass of slagged ash. The slag was approximately 22 in. deep, and it was necessary to remove it in order to continue operation. The slag was baled out with hand ladles until the level was lowered to a depth of 6 in., which made it possible to operate until the week end. At that time a hole was cut into the side wall below one of the ash doors and the slag was allowed to run out on the floor and chill. To say the least, a busy time ensued in handling this mass of slag. It was then decided to run the slag into a trough and sluice it to a pit about fifty feet from the boiler. Water at a pressure of 80 lb was available and one 2-in. nozzle, swedged to form a flat spray, was used below the tapping hole to break up the slag as it emerged. A second nozzle was located about twenty feet away from the boiler to sluice the slag to the pit.

This method of slag removal made it possible to operate the boilers at 300 per cent of rating and during 1933 three additional boilers were converted to coal firing with water walls and slag tapping in order to obtain more steam required for expanding plant operations.

CONSTRUCTION OF FURNACE BOTTOMS

The original flat bottom shown in Fig. 1 and designated as bottom No. 1 was installed with the original water walls. It consisted of the concrete pad with two flat courses of second-quality firebrick followed by two flat courses of first-quality firebrick. A vertical brick wall about two feet high was constructed in front of the lower water-wall bends to protect the wall boxes from the slag. This type of bottom lasted one year after slag tapping was started.

Fig. 2 illustrates bottom No. 2. It was built of mica-schist rock and consisted of 6 in. of rock built on 9 in. of brick. The mica-schist rock tended to loosen and float out with the slag so that this type of construction was abandoned after a period of six months.

Bottom No. 3 shown in Fig. 3 is now in use on five boilers and has given very satisfactory service for two years. It is still in use. It consists of three flat courses of first-quality firebrick on the top of the concrete pad, followed by a course of brick of the same quality placed on end. The brick are laid with dry ground joints, in a manner similar to the method of laying brick in the hearth of a blast furnace. The entire floor is then brushed with a thin fireclay grout. The wall boxes are protected by a 36-in. vertical firebrick wall faced with 6 in. of plastic chrome sloped out to the bottom. It required 18 hr and a total force of ten men to install this bottom.

Bottom No. 4, illustrated in Fig. 4, was built at the same time as bottom No. 3. It consists of one course of 9-in. firebrick laid on end with 6 in. of plastic chrome placed on top of the brick. This construction has also been in operation two years. It has been satisfactory and is still in good condition. It took six men eight hours to install this bottom. The cost of bottoms Nos. 3 and 4 is approximately the same, as the higher cost of plastic chrome in bottom No. 4 is balanced by the increased labor cost of building bottom No. 3 with the ground-joint brick construction.

OPERATION OF SLAG TAPPING

Slag is tapped from each boiler once every 24 hr and the slag level is lowered from 18-in. to 6 in. at these periods. Two men tap six boilers on one eight-hour shift, whereas it required eight men three shifts per day to dig the ash out of the furnace bottoms under the old method for each boiler cleaning period. The furnace bottom is sloped toward the tapping hole as shown in Fig. 5. The tapping hole is one course of brick $4^1/_2$ in. wide and six courses 15 in. high and is shown in section in Fig. 6.

When tapping slag, the top brick are removed first, and, as the slag level lowers, additional brick are taken out as required to keep the slag flowing. Fly ash is used to keep the slag

Contributed by the Fuels Division for presentation at the Semi-Annual Meeting, Cincinnati, Ohio, June 17 to 21, 1935, of The American Society of Mechanical Engineers.

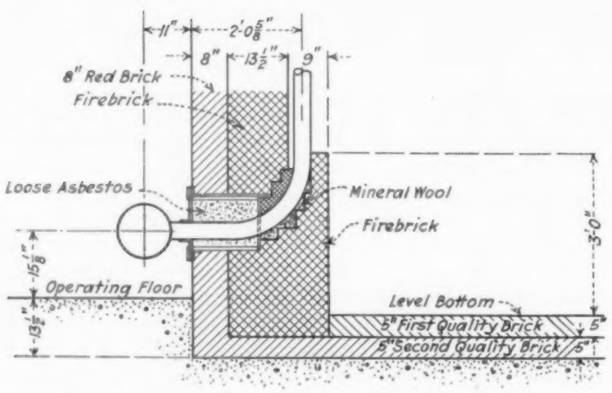


FIG. 1 BOTTOM NO. 1—LIFE ONE YEAR

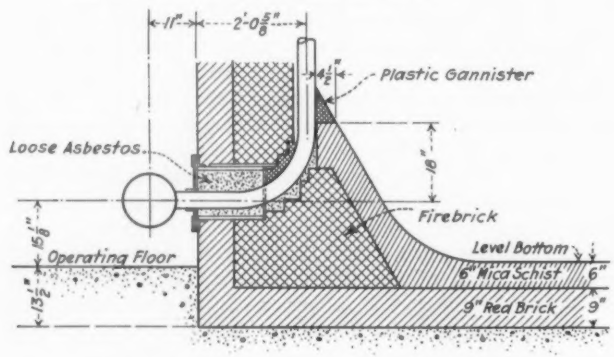


FIG. 2 BOTTOM NO. 2—LIFE SIX MONTHS

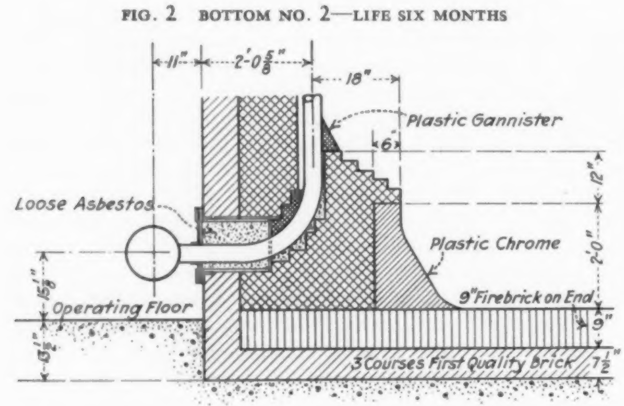


FIG. 3 BOTTOM NO. 3—IN USE TWO YEARS TO DATE

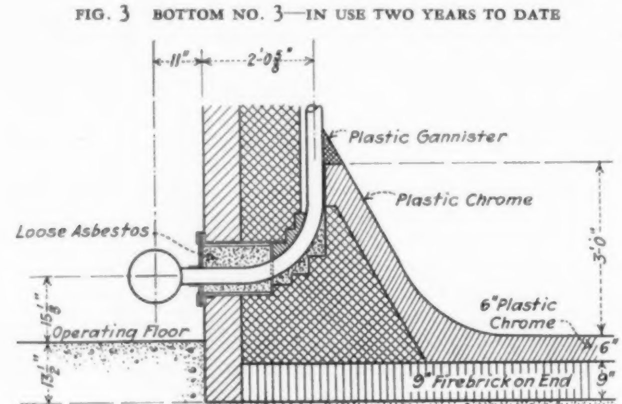


FIG. 4 BOTTOM NO. 4—IN USE TWO YEARS TO DATE

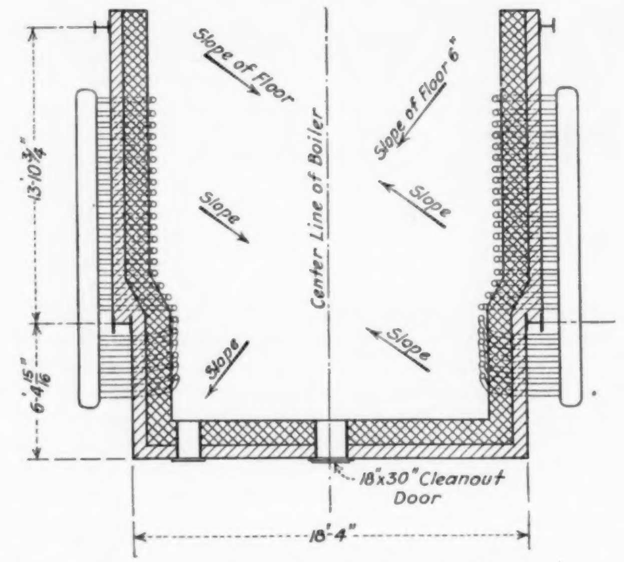


FIG. 5 PLAN VIEW OF FURNACE BOTTOM WITH FLOOR SLOPED SIX INCHES IN DIRECTION OF TAPPING HOLE

from sticking to the walls of the tapping hole and aids materially in keeping a steady flow of slag. In closing the tapping holes it is first cleaned, and then the brick are placed in position. Fly ash is used to fill the void inside the tapping hole and prevents the slag from adhering to the brick at that point. Fireclay is finally used to seal the tapping hole on the outside.

The boilers are operated the majority of the time on coal firing, but blast-furnace gas is used over week-ends. During these periods, the slag freezes in the bottom and it requires from twelve to eighteen hours of coal firing to melt this slag for tapping. The iron ore and limestone dust deposited from furnace gas act as a flux in melting the slag.

Boiler operating conditions are varied considerably, but the slag-tapping operation has been maintained successfully. In the furnace proper CO_2 is maintained at 14 to 15 per cent. The pulverizers are operated so that 98 per cent of the coal passes through a 50-mesh screen. As long as the coal is sufficiently fine to prevent sparklers in the burner, it has been found satisfactory for keeping the slag in a molten condition.

Some operating data are as follows: Ratings are from 40,000 lb per hr (140 per cent) to 80,000 lb per hr (300 per cent), with an average of 65,000 lb per hr (240 per cent). The furnace draft is 0.15 in. of water. The CO_2 in furnace is 14 to 15 per cent. Evaporation amounts to 10.2 lb of water from and at 212 F per pound of coal as received. The flue-gas temperature is 600 F; the boiler efficiency 77.5 per cent. The heat liberation in the boiler furnace varies from 10,500 to 16,500 Btu per cu ft.

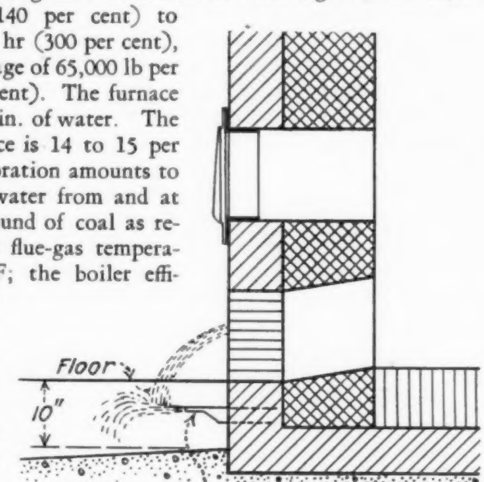


FIG. 6 SECTION THROUGH TAPPING HOLE

VENTURI *and* WEIR MEASUREMENTS

Forty Years of Comparative Records

By CHARLES M. ALLEN and LESLIE J. HOOPER

WORCESTER POLYTECHNIC INSTITUTE

During the past forty years a ten-foot contracted weir has been in use at the Alden Hydraulic Laboratory, of the Worcester Polytechnic Institute, under a great variety of conditions. During that same period all the water measured passed through a 36- by 16-in. venturi meter and in this way it was possible to calibrate one against the other. Since 1922 both the weir and the venturi meter have been accurately calibrated by the weighing tank at frequent intervals.

In 1894, when the original laboratory was built, it was the concensus of opinion of several noted hydraulic engineers that the contracted weir was probably more accurate than the suppressed weir as it could be more easily duplicated and the velocity of approach, being lower, would have less effect. In 1921 when the salt-velocity method was used in the 40-in. penstock it was discovered that the quantities as measured by this method and the weir did not agree by varying percentages over the range of discharge tested. It was at this time that the necessary equipment was installed to calibrate the weir by the weighing-tank method and the weir was found to be in error.

This paper records the results of this long series of comparisons of a 10-ft contracted weir and a 36- by 16-in. venturi meter.

APPARATUS

Water is supplied to the laboratory through 350 ft of 40-in. riveted steel pipe. (See Fig. 1.) It passes through a 36- by 16-in. venturi meter on its way to a 100-hp scroll-case wheel, discharging through a vertical diverging draft tube into the tail-race flume.

The 36- by 16-in. venturi meter is of standard construction with a brass-lined throat. As the head on the plant is 30 ft, water manometers have been used in measuring the venturi deflections. As a matter of historical interest, all of the water furnished the Chicago World's Fair in 1893 passed through this meter.

Water is supplied to the weighing tank through a 12-in. pipe line. Switching facilities are provided to divert this water over the weir or to waste. The timing of the weighing tank runs has been done either by calibrated stop watches or chronograph. In either case a contact on the switchway has operated the timing device so that personal error was eliminated at this point.

The flume in which the weir is located is 54 ft long and 16 ft wide. (See Fig. 2.) The weir crest has a free length of 10 ft, leaving contractions, at each end, of 3 ft. The crest and end contractions are made of bronze strip which was machined straight and sharp at the time of installation. The crest has been machined several times since, the last time being previous to the calibration of 1926. At the present time the crest of the weir is level within plus or minus 0.003 ft, and the mean height is used in determining the hook-gage zeros. The sharp edge of the weir has become rounded to a radius of about 0.01 in. and the surface of the bronze plate has become slightly roughened by the action of the water. In this condition the crest is stable in that changes occur very slowly. This is desirable when a weir is calibrated and when it is in continuous use.

Contributed by the A.S.M.E. Hydraulic Division and presented at a joint meeting of the Division and the American Society of Civil Engineers, January 17, 1935.

A perforated piezometer pipe traverses the weir flume 7.4 ft upstream from the crest and 2.5 ft below the crest. Stilling pots are connected at each end of the piezometer pipe and the head on the weir is measured by means of hook gages.

The history of the weir flume is briefly as follows: From 1894 until 1915 the weir flume had no obstruction in it of any kind. Then the 4.5-ft channel was installed together with the bulkheads and the 6- and 12-in. racks. These racks were made of 1-in. boards set on 2-in. centers. In 1925 a 3-ft glass-sided flume was erected on bents located in the weir flume. Two bulkheads were removed and a hole was cut into the side of the upstream, west, hook-gage pit. Water introduced at this point had to flow to the upstream end of the flume before entering the 4.5-ft channel. In November, 1932, the lower part of the siding of the 4.5-ft channel, the remaining bulkheads and the 6-in. racks were removed. In November, 1933, the 12-in. racks were taken out and in January, 1934, the 15-in. pipe and stilling box were installed. The other obstructions which were in the flume at this time were the baffles, the bents supporting the 3-ft flume, the upper part of the siding of the 4.5-ft channel, and the 2 by 6-in. posts supporting this siding.

PROCEDURE

The 12-in. line to the weighing tank has a capacity of about 6 cfs. Up to this amount the weir was calibrated directly; and for larger flows the increment method was used. This method consisted in adjusting a primary flow through the venturi meter and wheel equal to the calibrated flow of the 12-in. line while this line was being discharged into the waste way. This primary flow was measured by the calibrated weir and venturi meter. Then the calibrated flow of the 12-in. line was again diverted over the weir and the total flow was measured over the weir. This process was repeated up to the normal capacity of the plant. In this way the venturi meter as well as the weir is actually calibrated by the weighing-tank method.

From the first operation of the laboratory until 1922 a large number of comparative tests of the venturi meter and the weir have been made.

COMPUTATIONS

The Hamilton Smith formula was used in computing the discharge of this weir in this series of tests because it was considered the most accurate. Until 1922 the venturi coefficient was determined by measuring the discharge with the weir using the Hamilton Smith formula. Since then the venturi coefficient has been determined by the weighing-tank method.

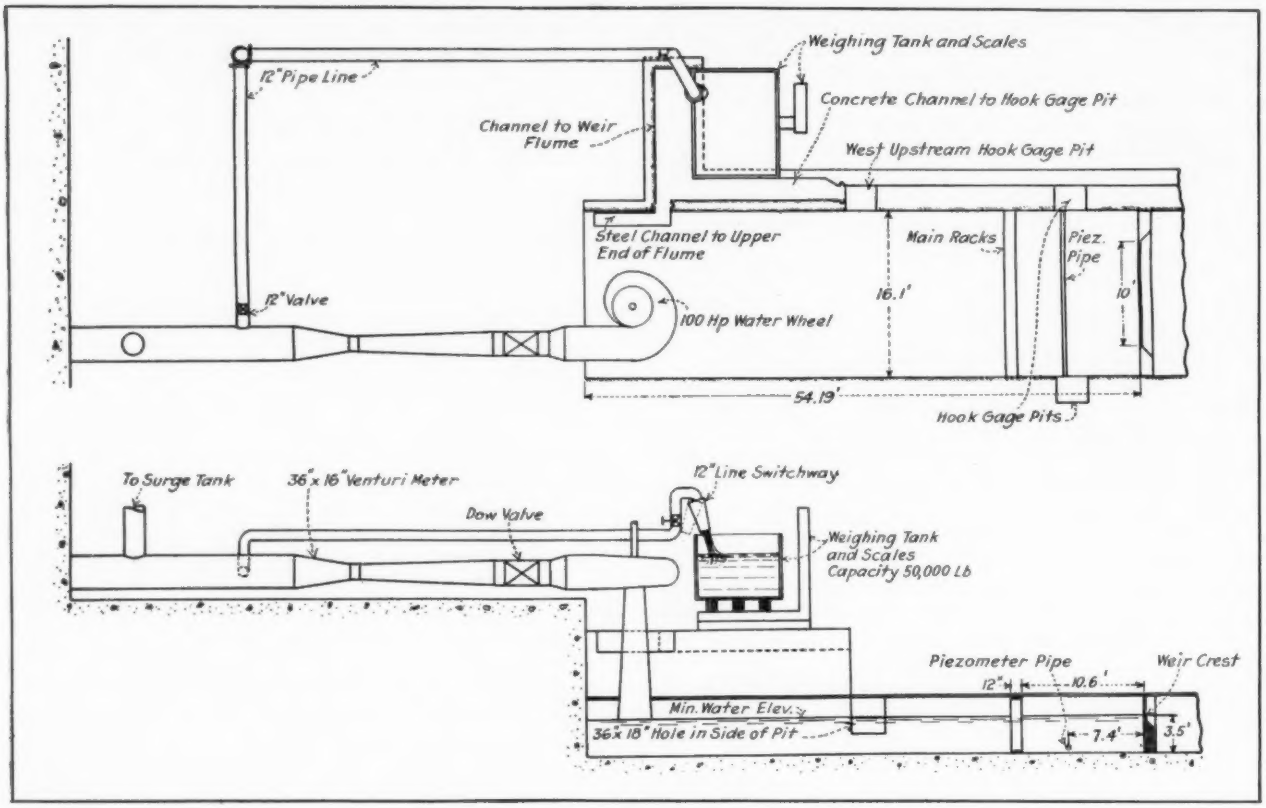


FIG. 1 LAYOUT OF APPARATUS USED IN CALIBRATION OF 10-FT CONTRACTED WEIR, ALDEN HYDRAULIC LABORATORY, WORCESTER POLYTECHNIC INSTITUTE

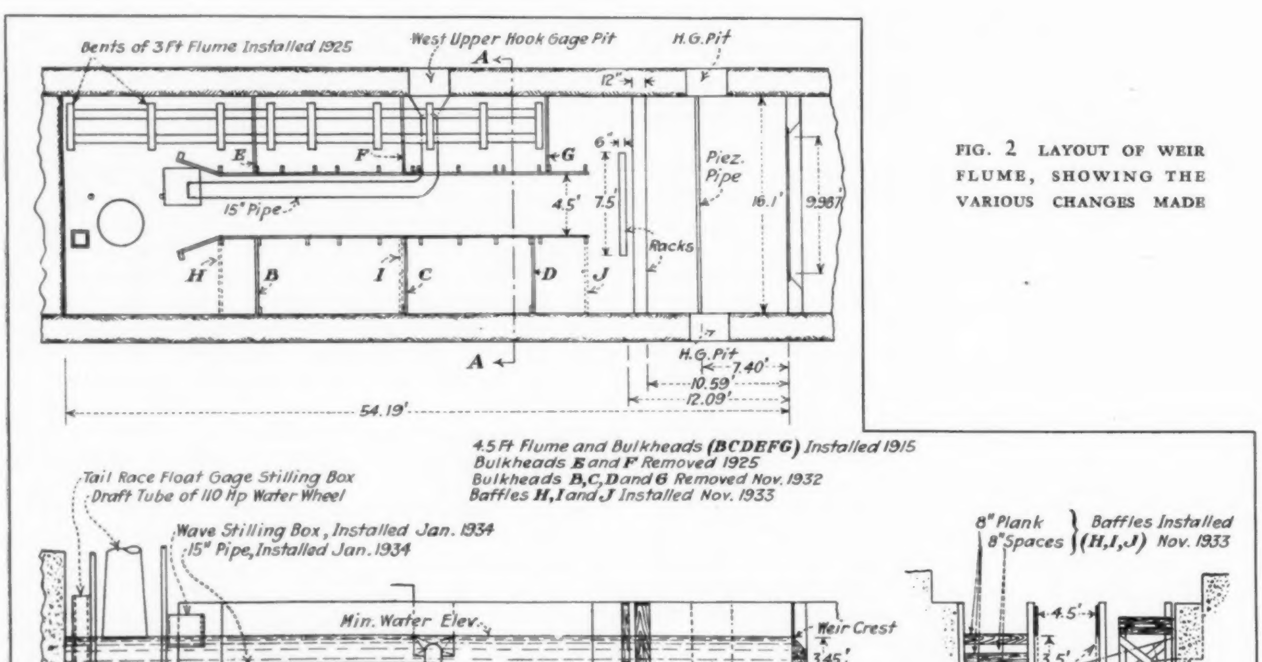


FIG. 2 LAYOUT OF WEIR FLUME, SHOWING THE VARIOUS CHANGES MADE

RESULTS

The results of these tests are shown in the diagrams. In Fig. 3 the average venturi coefficient (from 10 to 40 cu ft per sec) has been plotted against the year in which the test was made. The test points plotted as circles represent the calibration of the venturi by the weir using the Hamilton Smith formula. The average venturi coefficient derived in this manner is 0.950, but the variations are relatively large and erratic. The mean variation is 1.1 per cent but the maximum variations are minus 3.2 per cent and plus 2.9 per cent. The highest value is 0.978 in 1921 and the lowest is 0.920 in 1912.

in 1934 which plots one per cent below the smooth curve. The reason for this divergent point was a mossy growth on the walls of the penstock which developed very rapidly in the spring of 1934. This growth was about $^3/_8$ in. long and would lie flat when the penstock was drained. When this growth was removed with a high-pressure stream of water, the venturi coefficient returned to 0.954. Attention is called to the fact that there was no growth within 25 ft of the inlet of the venturi meter.

In Fig. 4 are plotted the weighing-tank calibrations of the weir from 1922 until November, 1932, at which time the 4.5-ft

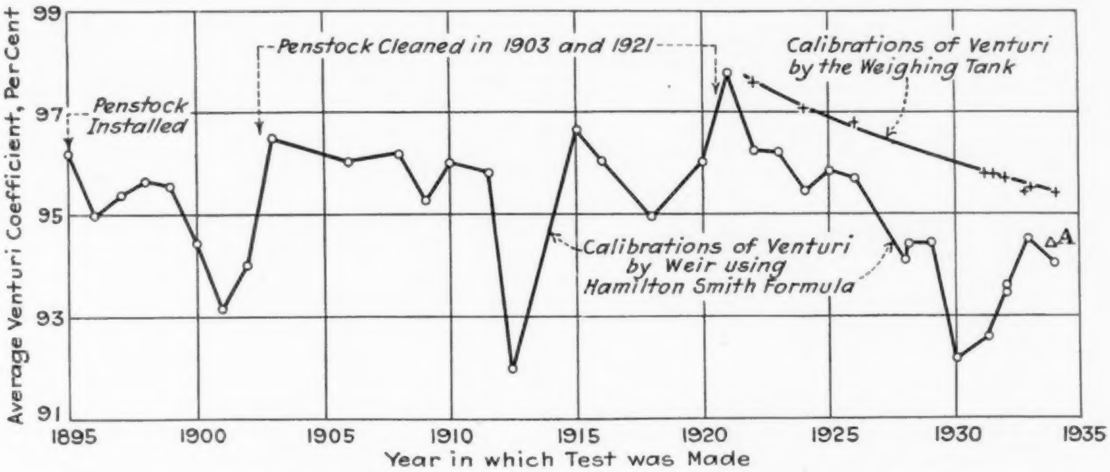


FIG. 3 CALIBRATION OF 36- BY 16-IN. VENTURI METER BY 10-FT CONTRACTED WEIR AND WEIGHING TANK
(A = Effect of mossy growth in pipe line on the venturi rating. No growth within 25 ft of meter.)

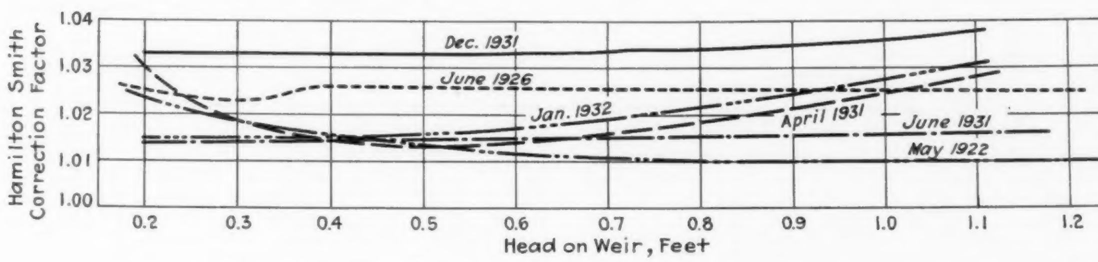


FIG. 4 WEIGHING-TANK CALIBRATIONS OF 10-FT CONTRACTED WEIR
(Correction factor is the number by which the discharge given by Hamilton Smith formula must be multiplied to obtain true discharge.)

By way of comparision the weighing-tank calibrations of the venturi meter are plotted on the same figure. It will be noted that the venturi coefficient in 1922 (within a year of the time that the penstock was cleaned) was 0.976 and it decreased uniformly until it reached 0.954 in 1934. A comparison of the weighing tank and the weir ratings indicates that the weir is responsible for many variations in the venturi rating.

The only reason for the decrease in the venturi coefficient over the period of twelve years was the condition of the walls of the penstock. In 1921 the penstock including the inlet cone of the venturi meter was scraped. The pipe factor of the penstock, which is the ratio of the mean pipe velocity to the maximum pipe velocity, was 0.84 and the venturi coefficient was 0.976. In 1934 the penstock was incrusted with tubercles giving a pipe factor of 0.78 and a venturi coefficient of 0.954. The tubercles collected on the inlet cone of the meter to a much less extent than in the pipe. The throat of the venturi meter, being of brass, has kept perfectly clean. There is one point (A, Fig. 3) on the weighing-tank rating of the venturi meter

channel was removed. The multiplying factor to correct the Hamilton Smith formula varies from 1.010 to 1.038. Within this range there is no systematic variation; some curves are horizontal while others are low at low heads and high at high heads and vice versa. The racks and flume were examined and cleaned periodically. Leaves and fish collecting on the racks and sand deposited on the floor on the upstream side of the racks apparently caused all of these variations and in no case was there any visible change in the flow conditions over the crest of the weir.

In Fig. 5 is shown the effect of cleaning the racks and the bottom of the flume. After the "before cleaning" test, the pit was drained and the racks inspected. Leaves were found over the bottom part of the 12-in. racks partially blocking it and a little sand was deposited on the floor, as indicated in the sketch. The leaves and sand were removed and the "after cleaning" test was made. The maximum change of 1.4 per cent occurred at a head of 0.2 ft on the crest, the effect diminishing to 0.3 per cent at 0.7-ft head on the crest and then

increasing again to 1.1 per cent at a head of one foot on crest. This non-uniform error was undoubtedly due to the varying velocity of approach conditions. The weighing-tank calibration of December, 1932, is also shown, as it was made under the same conditions as prevailed in the "after cleaning" test. The two curves agree within $^1/_2$ per cent except at 0.2-ft head, where the divergence is 0.7 per cent.

the water to the upstream end of the flume and the calibration of January, 1934, was made. In this instance the worst variations were caused at the low flows being 0.7 per cent at 0.2-ft head and decreasing to an exact check at 0.8-ft head on the weir crest.

Fig. 7 illustrates how rapidly changes can take place in a weir. December 28 and 29, 1931, the weir was calibrated by

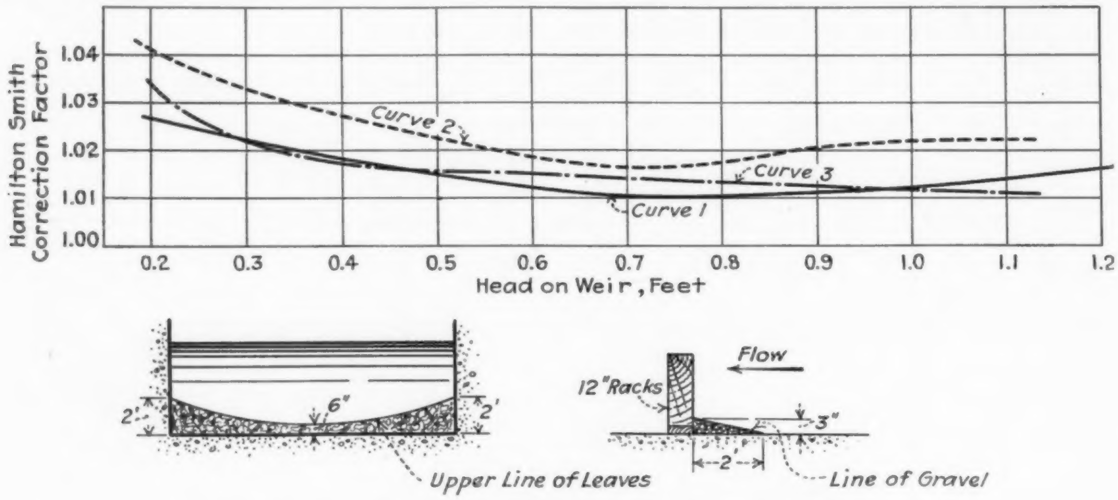


FIG. 5 CALIBRATION OF 10-FT CONTRACTED WEIR AND CONDITION OF RACKS

(True discharge = Correction factor × Hamilton Smith discharge. Curve 1 Weighing-tank calibration of December, 1932. Curve 2 Weir calibration before cleaning racks, November, 1933. Curve 3 Weir calibration after cleaning racks, November, 1933.)

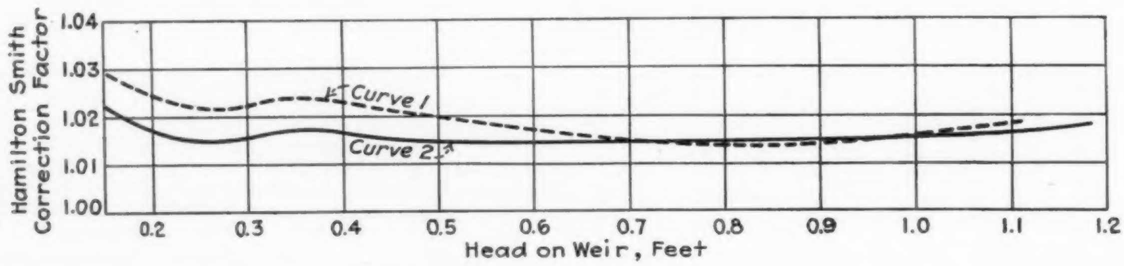


FIG. 6 EFFECT OF VELOCITY DISTRIBUTION ON CALIBRATION OF 10-FT CONTRACTED WEIR

(Curve 1 Water introduced at west upper hook-gage pit, November, 1933. See Fig. 2. Curve 2 Water taken to upstream end of flume by 15-in. pipe, January, 1934.)

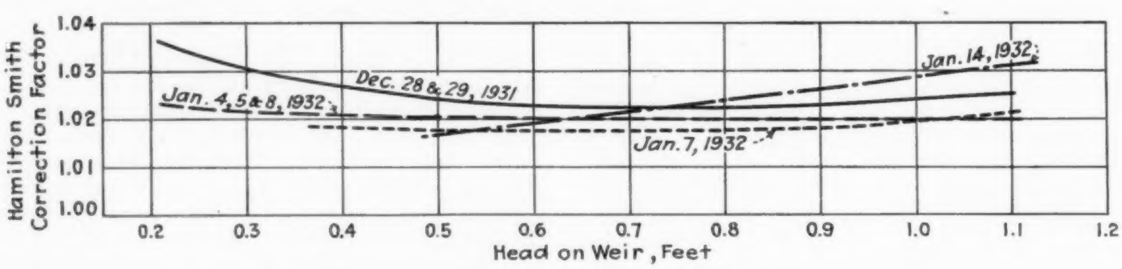
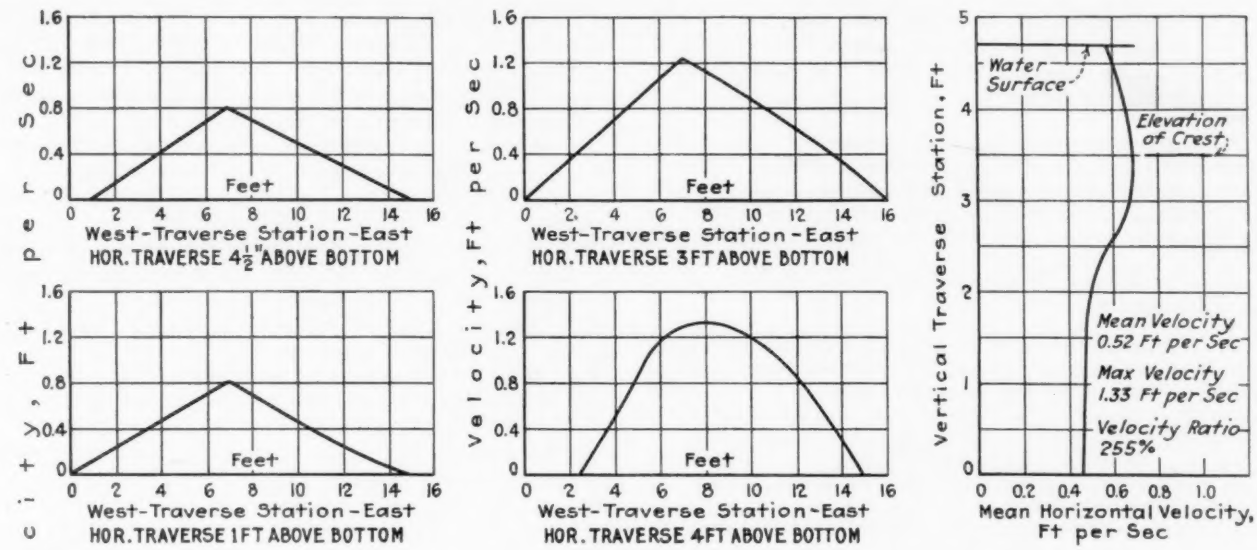


FIG. 7 CALIBRATION OF 10-FT CONTRACTED WEIR

(Racks and flume cleaned prior to calibration of Dec. 28, 1931. On Jan. 9, 1932, the weir flume was drained and one piece of $8^1/_2 \times 11$ in. paper and three short (3 to 9 in.) pieces of 2 by 4 timber found on racks.)

Fig. 6 shows the influence of the velocity distribution on the calibration. In the rating of November, 1933, the water entered the weir flume through the 3 by 1.5 ft hole in the side of the west upstream hook-gage pit. A test by the salt-velocity method showed that the weir was not operating as calibrated. Then the 15-in. pipe was installed to conduct

the weighing tank. It was not used until January 4, 1932, when a series of tests was started. The calibrations were computed from these tests. On January 9 the weir flume was drained and a piece of $8^1/_2$ by 11 in. paper and three small pieces of wood were found on the rack. Apparently, they caused the changes up until January 9. The reason for the



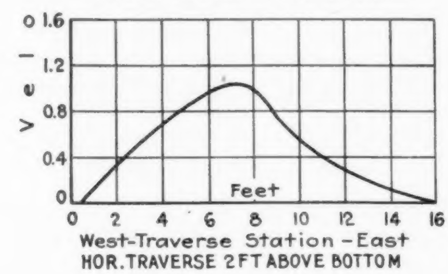


FIG. 8 CURRENT-METER TRAVERSE OF WEIR FLUME 3.2 FT ABOVE CREST SHOWING DISTRIBUTION OF VELOCITY OF APPROACH—DISCHARGE 39 CFS

change of January 14 was not determined. During these tests the weir calibration varied over a band from 0.5 to 1.5 per cent wide with no apparent reason.

During the calibration of January, 1934, current-meter traverses were made 3.2 ft upstream from the crest with a Gurley 6-in. enclosed-type special meter and the results are presented in Fig. 8. The discharge was about 39 cfs and the head on crest 1.12 ft. Computations from these curves give a mean velocity of approach of 0.52 fps, and a maximum velocity of approach of 1.33 fps. The maximum velocity is 255 per cent of the mean. The distribution of these velocities is clearly shown by the curves. An effort was made to equalize the velocity traverses by means of baffles located 20 ft upstream and beyond. While the velocities were made more uniform, the eddies and "boilers" produced were not entirely quieted down before the crest of the weir was reached.

Further tests were made to determine the effect of waves. With a head of 0.2 ft on the weir waves of a height of 0.08 ft from trough to crest were artificially set up in the weir flume. The same discharge was passed at a lower head, the change being 1.3 per cent in the apparent discharge. While this change of 1.3 per cent is large, the artificial waves were abnormal and the indications are that for normal flow conditions the effect of the ripples or small surges encountered is usually negligible.

During the calibration of January, 1934, some tests were made to determine the effect of velocity distribution. With a constant flow of 5.5 cfs being introduced through the steel channel at the upper end of the flume and passing over the weir, the indicated flow could be varied $^1/_2$ of 1 per cent by letting the water drop straight down or by deflecting it at 30 deg toward the center of the weir flume and parallel to the crest. The test was duplicated with a flow of 3.0 cfs. This change of $^1/_2$ of 1 per cent in the indication of the weir was produced by relatively slight changes in the velocity distribution 55 ft upstream or about 275 times the head on the weir. When the 5.5 cfs flow was introduced at one side of the flume at a distance of 17 ft upstream from the crest the variations became as much as 18 per cent by the computations of one hook gage and 9 per cent by the other. Both errors in discharge were negative. The head on the crest was about 0.3 ft.

Those who wish more detailed and quantitative information regarding the effect of velocity distribution are referred to the paper entitled "Precise Weir Measurements," presented to the American Society of Civil Engineers in 1929 by Ernest W. Schoder and Kenneth B. Turner.

FORTY-THOUSAND POUND WEIGHING TANK USED FOR CALIBRATION OF WEIR AND VENTURI METER

The following quotations taken from the "Lowell Hydraulic Experiments," by James B. Francis in the year 1852 indicate that the state of the art in regard to weirs has advanced but little since his monumental work.

No correct formula for the discharge of water over weirs, founded upon natural laws, and including the secondary effects of these laws, being known, we must rely entirely upon experiments, taking due care in the application of any formula deduced from them, not to depart too far from the limits of the experiments on which it is founded.

Then referring to the work on small weirs by Castel whose data he analyzed:

It will be seen by referring to the last column, that the proportional differences are considerably greater, and have less uniformity than in the comparison with the experiments of Poncelet and Lesbros; nevertheless, there is a certain harmony in the results of both comparisons, and they serve to show how unsafe it is, in the present state of the science of hydraulics, to apply rules to gauging streams of water passing over weirs, of which the dimensions differ greatly from those in the experiments from which the rules have been deduced.

It not infrequently happens that, in consequence of the particular form of the canal leading to the weir, or from other causes, the velocity of the water in the canal is not uniform in all parts of the section; this is a frequent cause of serious error, and is often entirely overlooked. If great irregularities exist, they should be removed by causing the water to pass through one or more gratings, presenting numerous small apertures equally distributed, or otherwise, as the case may require, through which the water may pass under a small head; these gratings should be placed as far from the weir as practicable.

SUMMARY

(1) Attention is called to the fact that the weir calibration of the venturi meter as plotted in Fig. 3 includes the errors of the Hamilton Smith formula as well as the inaccuracies of the weir for the forty-year period. The venturi meter coefficient as determined by the weir varies from 0.920 to 0.978.

(2) The weighing-tank calibration of the venturi meter as plotted in Fig. 3 gives a coefficient of from 0.954 in 1934 to 0.976 in 1922, at which time the penstock and venturi were cleaned. The departure of any point from the smooth curve is not greater than $^1/_4$ of 1 per cent.

(3) The velocity distribution in the weir channel of approach is very important in duplicating test conditions.

(4) The channel of approach should be long and uniform in section.

(5) If stilling racks are necessary in the approach channel of a large weir, of the size mentioned in this paper, they should be upstream at least 25 times the head on the crest.

(6) Where stilling racks are used they must be continually examined and cleaned if necessary.

(7) Even though a weir is permanent and substantially built, the hook-gage zeros must be accurately and continually checked since this measurement affects all head readings.

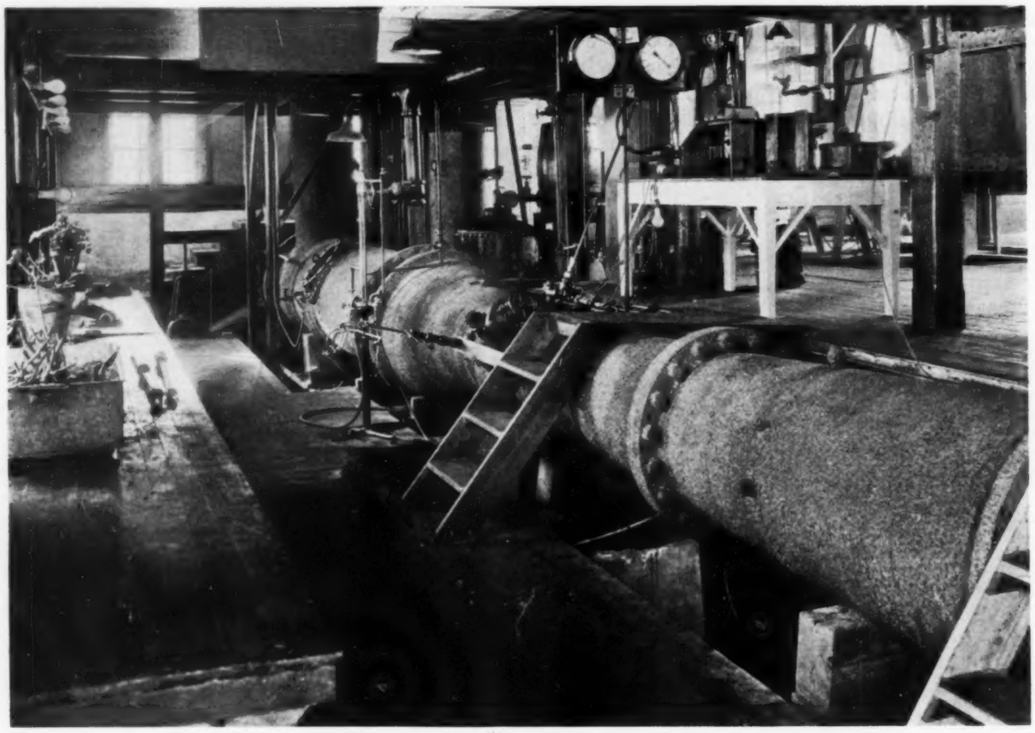
(8) A study of these results indicates that a weir will give the discharge within 2 per cent under a wide range of conditions provided approach conditions are good. Poor approach conditions can cause errors up to 15 per cent under low crest heads.

(9) Although the Hamilton Smith formula was derived from weirs of substantially the same characteristics as the one under discussion, it fails to give the true discharge as determined by the weighing tank by about $1^1/_2$ to 2 per cent.

(10) If a weir formula is to be used, the specifications including the velocity of approach conditions must be exactly duplicated.

If these conditions are not fulfilled, the weir must be calibrated for accurate work.

(11) The weir and venturi meter are apparently in the same class with most other methods of water measurement in that they must be carefully calibrated under the conditions of use in order to give results with an accuracy of $^1/_2$ of 1 per cent.



VIEW OF 36- by 16-IN. VENTURI METER

LABOR'S DILEMMA *in* DEPRESSION

By LINCOLN FAIRLEY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Economics written by engineers has become so common a phenomenon in the last few years that books on this subject are no longer news. But when an economist turns engineer it is a case of the man biting the dog. Moreover, the eminence of Professor Douglas[1] is such that we may safely guess in advance that there will be a real story following the headlines.

"The Theory of Wages" has a title forbidding to the practical man and contents forbidding to the casual reader. But it is a book thoroughly repaying careful study. It is a pioneer attempt to examine statistically an area hitherto analyzed only abstractly. The book begins with a remarkably readable and compact summary of the development of the now generally accepted theories of how the national product is divided among wage-earners, capitalists, landowners, and business enterprisers. But the bulk of the volume is devoted to an attempt to test by statistical means the validity of these theories and to obtain numerical data to insert in hitherto abstract formulas. The volume's major contribution and its primary interest for engineering readers lie in this latter section.

LABOR'S REWARD TENDS TO EQUAL ITS CONTRIBUTION

The basic rate of wages, that rate paid for an hour of labor of minimum intensity, skill, and ability, is said by economists to be determined under assumed conditions of perfect competition—among workers for jobs and among employers for labor—by labor's marginal productivity. This means that labor's reward tends to equal its specific contribution to the joint product which it produces with the assistance of capital, land, and business enterprise. Employers of labor cannot pay it more than it is worth. This proposition is logically valid under the assumed conditions. The theory can, indeed, be stated in formal mathematical symbolism. But are not the assumptions—Douglas lists ten—so at variance with facts that the theory is practically of no importance? Perfect mobility of labor and capital we know to be fiction. Combinations among employers or among employees in some industries make a farce of free competition. Unemployment, assumed to be non-existent, is one of our knottiest problems. Hence, if many of the basic assumptions are false, is not the whole theory vitiated?

The answer, according to Professor Douglas, is "No." The theory, when tested statistically, is found to conform surprisingly well with the facts. To explain such agreement, despite the unreality of the assumptions, we must suppose that divergencies of the facts from the assumptions pretty much cancel out. The author's method is to examine manufacturing industry for the period of 1899–1922 with a view to finding what relationships actually existed among statistical series for the increase in the labor supply (man-hours), in capital equipment, and in physical production. He finds that labor supply increased 60.5 per cent, capital equipment 331 per cent, and physical output 140 per cent. He starts with the formal statement that physical output P is a function of the number of man-hours worked L and of the quantity of fixed capital utilized C, or in the usual symbolism, $P = f(L, C)$. Then, using the numerical data showing changes in these factors over the period studied, he derives the product function $P = 1.01\ L^{3/4}C^{1/4}$. Labor, speaking metaphorically, was responsible for three-fourths of the total physical output of manufacturing industry during this twenty-three year period.

THEORY FINDS STATISTICAL SUPPORT

The next step: Does this figure correspond with such data as we possess regarding the manner in which P was divided among the factors of production? Yes. Fragmentary studies of income distribution suggest that wages constitute about 70 per cent of the total national income. Since the wage share in manufacturing alone is rather larger than it is in all industry taken together, 75 per cent is thought to be not far from correct. Hence, he believes, the theory of wages finds some statistical support.

It will, of course, be recognized from the form of this last statement, that Professor Douglas's conclusions are merely a rough first approximation. Indeed, he lays no claim to precision. His interest is to start the ball rolling toward statistical verification of abstract theory and he recognizes hopefully the certainty of a high obsolescence rate for his particular method. This branch of economics is scarcely at the threshold of precision.

So far, Professor Douglas has been deriving a law of production. From this formula $P = 1.01\ L^{3/4}C^{1/4}$ he proceeds to determine the form of the demand function for labor. He proceeds, that is, to use a historically derived formula for algebraic manipulation, a procedure open to considerable question. His results, however, are interesting. We have known by using the abstract statement $P = f(L, C)$ that as the number of workers increases, productivity per worker falls. And as productivity falls, so does the demand for additional workers. But to the question: How rapidly does productivity fall?—we have had no answer. Now we have a preliminary and partial one: An increase in wage rates of one per cent would decrease marginal productivity of labor by four per cent and hence the quantity of labor demanded by a like amount. Or, employers could afford to hire four per cent more workers if wages were reduced one per cent. In the technical language of economics the demand for labor exhibits a negative elasticity considerably greater than unity ($\epsilon = -0.4$).

SOME IMPLICATIONS OF THE THEORY

Instead of proceeding further to report Professor Douglas' statistical conclusions regarding the actual dimensions and forms of the demand and supply functions for labor and for capital, let us consider some implications of the statement just made, that if wage-rates were reduced by a certain percentage the demand for labor would increase more than proportionately. Does this argue that labor would be well advised voluntarily to reduce its wages during a depression in order to absorb a more than proportionate number of the unemployed? In view of the foregoing an affirmative answer appears obviously to be called for. Not only is labor cost approximately three-fourths of total cost, taking industry as a whole, but a reduction in wage rates would increase employment more than proportionately.

[1] "The Theory of Wages," by Paul H. Douglas. New York, The Macmillan Company, 1934. Cloth, 6 × 9 in., 639 pp., \$5. College edition \$3.75.

It is, of course, true that an increase in the number of workers whom manufacturers can afford to hire does not necessarily mean an increase in employment. How many shall be employed depends in addition upon how many workers offer themselves for work at the lower wages. In most instances, probably, it is safe to say that a demand for more workers will, in time of depression, be met by applications from hitherto unemployed workers. But if wage levels get to the abysmal depths reached in some occupations during the current depression, it is possible that employed workers will leave employment for the relief rolls. However, relief allowances have not, in general, been sufficient to tempt any large number of employed persons to leave their jobs. Scattering cases, of course, can be cited to prove the opposite, but careful observers both here and in England have been unanimous in finding that the great majority of workers prefer jobs to relief.

But this qualification is a minor one. It seems substantially true, on the basis of the evidence quoted, that in our economy activated as it is very largely by anticipations of profit, substantial wage reductions would tend to make profit prospects more rosy and so to stimulate recovery and reemployment. But Professor Douglas, in a more recent volume,[2] seeks to prove that the failure of wage rates to drop as readily in a depression as do some other prices is by no means the primary influence prolonging depressions.

"CONTROLLING DEPRESSIONS"

"Controlling Depressions" will no doubt appeal far more to the general reader than "The Theory of Wages," since it is written in non-technical language and deals with the phenomena of prosperity and depression rather than with so-called long-run issues. It is one of a group of recent books by distinguished economists devoted to the discussion of these currently important topics. Two others which may be mentioned are Sumner H. Slichter's book entitled, "Towards Stability," and J. M. Clark's, "Strategic Factors in Business Cycles."

Professor Douglas' argument on this point, stated very briefly, is that in the years 1929–1933 labor costs, instead of being relatively rigid, actually fell more rapidly than prices of manufactured goods. These latter prices, moreover, he points out, were much more rigid than raw-material prices. He concludes that the price rigidity which is a serious factor in deepening and prolonging depression is not wage rigidity but the rigidity of prices of manufactured goods. Price-maintenance policies, designed to protect profit margins, make necessary output curtailment, workers lose jobs, or are put on part time, purchasing power is curtailed, unemployment is spread to other industries, and the vicious circle goes on.

WHAT SHOULD LABOR'S POLICY BE?

But the same facts can be considered somewhat differently. The employer at such a time, faced with the problem of cost reduction, finds that labor costs are the largest single cost item, and, in addition, are the most readily adjustable costs. Interest charges cannot be reduced or defaulted; taxes continue as large as before or are even increased; and the fall in raw-material prices is not enough to accomplish the necessary result. Hence, the pressure on labor costs which causes them to fall faster than prices of manufactured goods. Wage rates are reduced where they can be, new methods are put into use, and production is concentrated on the most efficient workers.

In the face of this situation what should be the policy of organized labor? If labor seeks to maintain its wages the effect is to force employers to adopt price-maintenance policies and unemployment results. If, on the other hand, labor passively accepts reductions, it is making sacrifices while bond holders, and to a lesser extent, other property owners, are enjoying a continuing income and lower prices of the things they buy. Here is labor's dilemma.

[2] "Controlling Depressions," by Paul H. Douglas, W. W. Norton Co., Inc., New York, 1935. Cloth, 6 × 9 in., 286 pp., $3.

ATTEMPTS AT SELF-PROTECTION

Organized labor reacts in this situation precisely as does any other organized economic group. It seeks to protect its existing status just as an industry protected by a tariff would object to removal of the tariff. Labor leaders in justifying their opposition to wage reductions make several points. They ask: Why should we make concessions, while owners make none? Wage disbursements in certain selected industries where wages and salaries could be separated, fell 60 per cent in 1929–1932, while interest payments fell less than 4 per cent. Moreover, the labor leaders point out that wage rates go down more easily than they can be brought up again. Since all increases have to be fought for, it is unwise voluntarily to take reductions. And finally, they insist that such action would be suicidal to their organizations. Why should members pay dues to an organization, the purpose of which is to increase their income and to obtain security for them, but which at the first appearance of adversity weakly accedes to employers' demands for relief?

LABOR'S DILEMMA

We live in an economic world which by its very nature is subject to severe, and very likely to increasingly severe, business fluctuations. Against the depression phase of these fluctuations every group seeks to protect itself by methods which for the most part accentuate the very difficulties which necessitated them. Unfortunately for labor, the legal and economic set-up is such that labor, being least able to protect itself, is the group which suffers most. Its wages rise more slowly than the cost of living on the upswing of the cycle, and unemployment is its common fate on the downswing. And the more it seeks to protect itself in the depression period the more it aggravates existing tendencies toward output restriction and unemployment. This is labor's dilemma.

A Twenty-Hour Soap Film

AT UNION COLLEGE, Schenectady, N. Y., there has been developed a soap film that will remain intact for as long as twenty hours. The soap is made of triethanolamine and either oleic or stearic acid. After this soap is made it is dissolved in a solution of glycerine using distilled water. One part triethanolamine and two parts of oleic acid are used. These two ingredients are heated together in an evaporating dish for about 10 minutes until all the excess amine is gone. It is very important that there be no excess of oleic or stearic acid. If the stearic acid is used then the stearic must be melted down alone. This is done in the usual way. The glycerine solution into which the soap is dissolved, is a 50 per cent solution.

This soap film is admirably adapted for use with the soap-film-analogy apparatus. This apparatus is used to find the torsional stress in bars subjected to twisting, i.e., bars that have cross-sections other than circular. The soap was developed by A. J. Palermo, of Union College, two years ago after he had tried many other soaps only to find that their films would burst at the end of a few minutes.—A. J. PALERMO.

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Improved Exhaust Tail-Pipe for Aircraft Engines

THIS device was developed in the engine laboratory of the National Research Council of Canada. Instead of having the usual back pressure on the system, with the new pipe there is a slight suction which tends to draw the exhaust of the system more rapidly and should result in lower maintenance and longer valve life, as well as in a cooler running engine. Fig. 1 in the original article gives drawings illustrating the air flow around a National Research Laboratory tail pipe and around a standard tail pipe. In the standard pipe the flame at the outlet of the various pipes tested is very thin and distribution is not even while in the "straight through" and N.R.L. pipes the exhaust gases take full advantage of the opening. A full report is not yet available. The original article contains drawings illustrating various types of tail pipes used in the experiments. (M. S. Kuhring, Engine Laboratory of the National Research Council of Canada, *Canadian Aviation*, vol. 8, no. 2, February, 1935, pp. 10–11, illustrated)

AIR ENGINEERING

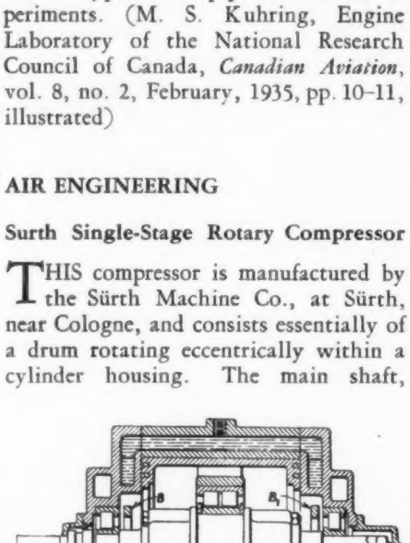
Surth Single-Stage Rotary Compressor

THIS compressor is manufactured by the Sürth Machine Co., at Sürth, near Cologne, and consists essentially of a drum rotating eccentrically within a cylinder housing. The main shaft, which is direct-coupled to the driving motor, is in the form of an eccentric within the casing and carries the drum on roller bearings. Sealing rings are fitted between the drum ends and the casing covers. The drum rolls around on the inner surface of the casing, the only sliding contact being between the drum and two control slides A and A_1, Fig. 2, which are located in slots in the housing and interconnected by rods B and B_1, Fig. 1, so that they move as one unit. The two rods are of banjo form being made up of a central ring provided with lugs to which the circular arms are pinned. Each of the slides is provided with a recess which, as shown in Fig. 2, acts as a valve controlling the air admission.

The slides subdivide the space between the drum and housing into an upper and lower compression chamber, so that two compression cycles occur during each complete revolution of the shaft. Each chamber is provided with its own outlet valve, C and C_1. In the position shown in Fig. 2, the space D is increasing, so that air will be drawn through the inlet as soon as the valve opens. The space E, on the other hand, is decreasing, so that the air in this space will be forced through the outlet valve. After the peripheral contact line has traveled past this valve, the spaces D and E become one, and reach their maximum volume when the contact line is at the lowest point, that is, after half a revolution. The valve A is then closed, and the air in the whole of the upper space is compressed for a further quarter revolution. During the final quarter revolution, the contact line again divides the upper space into two chambers, compression continuing in the space E until the position shown is reached. The cycle in the lower space F is identical with a lag of 180 deg.

The compressor is suitable for compressing air or gas up to 85 lb per sq in. gage. The machine may also be used for producing a vacuum in one or two stages up to 0.04 kg per sq cm abs, or 0.3 mm of mercury.

The power consumed per cubic meter of air is shown in the original as a curve in functions of pressure. It is said that the lubricant is not atomized and the air delivered is free from oil. (*Engineering*, vol. 139, no. 3607, March 1, 1935, pp. 227–228, 6 figs.)



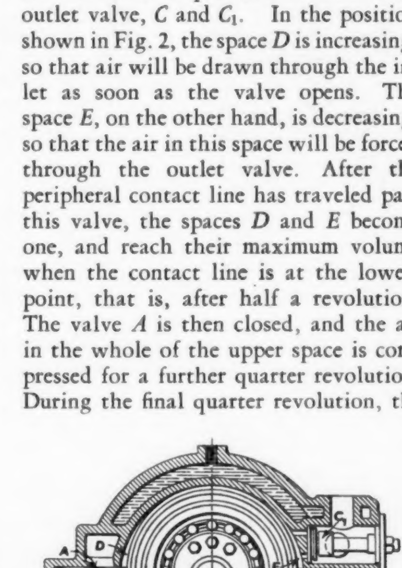


FIG. 1 (LEFT) AND FIG. 2 (RIGHT) SURTH SINGLE-STAGE ROTARY COMPRESSOR

AIR MACHINERY

Rotary Compressors for Refrigerating Machinery

THREE types of apparatus may be used for compression of gases, namely, reciprocating-piston machinery, centrifugal machinery, and rotary machinery. The basic purpose of employing rotary machinery is to avoid the heavy crankshaft drives and to reduce the reciprocating motion of piston masses. It would appear that the elimination of reciprocating pistons permits raising the speed of the machine to such an extent that it can be directly coupled to standard electric motors. Other points in favor of the rotary compressor are the elimination of the suction valve and at times also the pressure valve and the reduction of friction against the walls, the latter being due to the fact that the material operated on always flows in the same direction in the rotary compressor.

As compared with centrifugal compressors the rotary compressor has the advantage that it can be operated with a satisfactory degree of efficiency in small and medium sizes and secures a higher compression ratio per stage. Because of these advantages, rotary compressors have been employed recently in the compressed-air industry and in refrigerating machinery. It is therefore somewhat surprising to find that they have not at-

tracted sufficient attention in technical literature.

On the other hand, several machinery manufacturers, who with great hopes have undertaken the construction of rotary compressors, have been disappointed with the result, because the efficiency of the machine did not satisfy expectations and the wear of the parts was high. In particular, where higher compression ratios per stage were attempted there have been material leakage and high frictional losses. This is due to the fact that construction of rotary compressors requires workmanship of a higher precision than is necessary in reciprocating-piston compressors. On the whole, it would appear, therefore, that a high efficiency, long life, large outputs, and higher compression ratios per stage can be secured only in shops where the tolerances are held within much closer limits than is necessary in the manufacture of reciprocating-piston machinery.

The author distinguishes the rolling-piston compressor I, and the rotary-piston compressor II. In the former the geometric axis of one element rotates with respect to the geometric axis of the other element, one element running substantially in a hypocycloid over the other member. In the rotary-piston compressor the geometric axes of both elements are held rigidly in place and one or the other element can rotate only about its own axis. In both cases, either the cylinder or the piston may be driven.

In refrigerating machinery rotary compressors have been used for fifteen years, but it is only quite lately that a rapid increase in their adoption has been noted. In order to reduce leakage losses it is desirable to operate with cooling mediums having a low vapor pressure, such as sulphur dioxide, tetrafluordichlorethane, ethyl chloride, methyl formiate, and methylene chloride. If for some reason it is desired to operate with fluids having a higher vapor pressure (ammonia, methyl chloride, difluordichlorethane), the increase in leakage losses may be counteracted by a substantial increase in the number of cells (up to thirty). The vapor pressures of the more important cooling media at —10 C in the evaporator and +25 C in the condenser are given in a table in the original article. The low-pressure cooling media are not suitable for operation in compressors with reciprocating pistons, as with such media the drop of pressure in the suction valves where the suction pressure is less than 1 atm abs, affects results disastrously. In rotary compressors there are no suction valves but only ports controlled by the pistons.

The author presents a description, including a brief history, of the various types of rotary compressors. He starts with a reference to the Pattison pump, patented in England in 1857, and to the Knott pump, patented in 1863. Of the more modern types he mentions and describes in detail the Rollator compressor of the Norge Corporation in Detroit (not abstrated as the machinery is well known in this country). The D.K.W. compressor of the German Refrigerating and Power Machinery Co. works with sulphur dioxide like the Norge and is a modification of the design of the latter. Next come the Frigidaire, General Electric, Bosch, and Vilter compressors, all made in the United States.

From this the author proceeds to the discussion of two-cell compressors, and points out that whereas single-cell rotary compressors operate mostly on the principle of a rolling piston, the two-cell and multiple-cell units use the rotary piston. This is due to the fact that in the rolling-piston type as many suction and pressure passages are required as there are cells, and that in the multiple compressors the stroke for the same main dimensions of the machine can be better utilized with a rotary piston. The author shows it in detail by giving diagrams for the operation of one-cell, two-cell, four-cell, and eight-cell compressors. As a matter of fact, however, the Vilter Manufacturing Co. in the United States builds a two-cell rolling-piston-type compressor and a compressor of the same type is also built by the machinery manufacturing company, Hermann Reis & Co., in Essen, Germany.

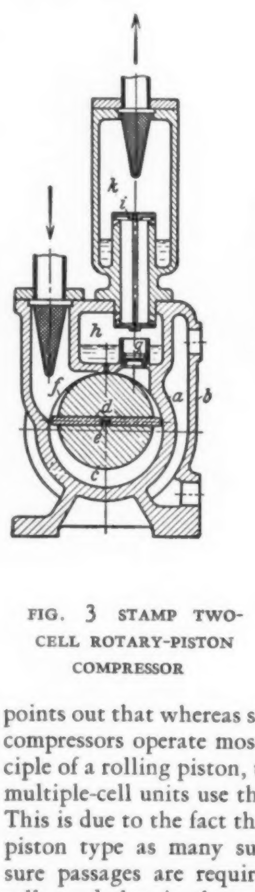


FIG. 3 STAMP TWO-CELL ROTARY-PISTON COMPRESSOR

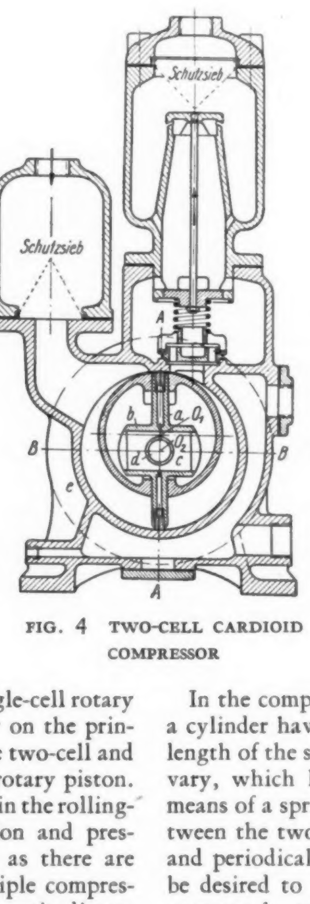


FIG. 4 TWO-CELL CARDIOID COMPRESSOR

Fr. Stamp, of Bergedorf, built a rotary-piston compressor for an output of cold of 1000 kcal per hr. This compressor operates at 500 rpm and uses ethyl chloride as a cooling medium. The cylinder *a*, Fig. 3, on the pressure side is provided with a water jacker *b*. The piston *c* eccentrically located in a cylinder of circular cross-section has a pure rotary motion and is provided with a two-piece slide valve *d*. The two halves of the valve are pressed against the periphery of the cylinder by a spring *e* located between them. The suction port *f* is located so low that a connection between the cylinder and the suction chamber is broken exactly when the slide valve comes to a horizontal position. This is said to give the greatest possible output of the pump. The compressed vapors are conveyed to the pressure chamber *h* by a plate valve *g*. Unlike what happens in two-cell rolling-piston compressors, there is only one suction and one pressure port, no matter what the number of cells of the compressor may be. The separation between the lubricants and the cooling media takes place partly in the pressure chamber *h* and partly after the stream of vapor has been deflected by the baffle *i* into the air separator proper. The oil separated out is carried back into the cylinder by the pressure in the liquefier.

In the compressor just described, with a cylinder having a circular section, the length of the slide valve must necessarily vary, which has been provided for by means of a spring (*e*, Fig. 3) located between the two halves of the slide valve and periodically compressed. Should it be desired to use a rigid slide valve of constant length, then the profile of the cylinder has to deviate from the circular shape, and if the slide valve is automatically controlled the profile of the cylinder is determined thereby. Such a two-cell rotary-piston compressor with automatically controlled slide valve is built by the Standard Refrigerating Machinery Works, Hamburg, Germany, under the trade name of Cardioidal compressor. It is built for outputs of from 500 to

30,000 kcal per hr, and runs on ethyl chloride.

The rigid valve a, Fig. 4, is provided with a link b, located at right angles to the plane A-A and permanently connected to the valve. The axis B-B of the link passes exactly through the center line of the slide valve. The link b moves on a sliding block c, which, in turn, is permanently connected to shaft d, the axis of which is normal to the plane of the drawing. The shaft in its turn is located in a stationary cylinder with axis O_2. When the piston rotates about its axis O_1, the slide valve a is carried with it, causing the link b to slide on the sliding block c. This can turn only with the shaft d and the axis O_2. In the cross-section shown in Fig. 4, the center point of the slide valve describes a circle of diameter O_1O_2. The axis A-A of the slide valve passes in every position through the point O_1 and the horizontal axis B-B of b, which means through point O_2.

The conchoidal compressor comes next under consideration. It is not stated whether or not such compressors are manufactured. The theory is stated, however, in considerable detail. The following is intended merely to give an idea as to the basic principles of this kind of compressor. The motion of the slide consists in a rotation about the center of the piston O_1 combined with the displacement thereof in the piston slot (Fig. 5). In this figure the cylinder and piston have been displaced 90 deg as compared with the position in Fig. 4 in order to make it possible to consider them kinematically in the ordinary position of the axes of coordinates. The center M of the slide having a constant length 2 R is located in a horizontal plane at point O_2. This center M is automatically carried along the circle with center C and diameter $O_1O_2 = 2a = R - r$, in such a manner that the slide all the time passes through the center O_1 of the piston having a radius r. The point M moves along a circle of diameter $R - r$ retaining a uniform angular velocity which is twice as great as the uniform angular velocity of the rotation of the piston. When the piston has moved through an angle of 90 deg, the point M has described half a circle. For any position O_1M of the slide there will be then two points P and P' on the perimeter of the cylinders determined by plotting a distance r on both sides from point M. The geometric locus of the point P and hence the equation for the shape of the perimeter of the cylinder is found most simply by displacing the origin of the coordinates toward O_1 and by representing the guide line $\rho = \overline{O_1P}$ as a function of the deviation φ, which gives

$$\rho = \overline{O_1M} + \overline{MP} = 2a \cos \varphi + R \quad [1]$$

The curve expressed by the above equation is a generalized conchoid. The original article states the difference between this curve and the conchoid of of Nikomedes. The curve according to Equation [1] differs from the ordinary conchoid only by the fact that a guide circle of diameter $2a = R - r$ passing through the center O_1 is used instead of the guide lines. Such circular conchoids have been known for a long time and among other things the author shows how for certain special values the conchoid might pass either into a cardioid or into a epicycloid. In this case, however, it has been assumed that $2a = R - r$, which means, in turn, that in the cardioid compressor of this particular type no material piston can be used.

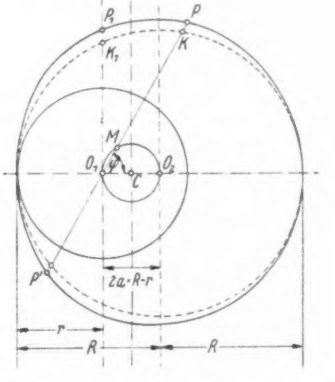


FIG. 5 KINEMATIC ANALYSIS OF A TWO-CELL ROTARY-PISTON COMPRESSOR WITH AUTOMATICALLY CONTROLLED SLIDE VALVE OF CONSTANT LENGTH

The next question which the author discusses is whether the conchoid perimeter of the cylinder may be replaced by a circle of diameter $2r$ and center at O_2. This depends entirely on the tolerances used in manufacturing. This part is not suitable for abstracting, but the conclusion to which the author comes is that special lathes are necessary to produce the cylinder, because its shape has to be held closely to that of a circular conchoid and it is only in very small units that a circle may be used instead of a conchoid.

The author discusses next multi-cellular compressors and generally establishes formulas for the single-cell, two-cell, four-cell, eight-cell and n_z-cell compressor. He shows that there are certain important advantages in the use of multi-cellular compressors. From this he proceeds to a mathematical treatment of the compression cycle and the matter of inclined positioning of the slides. He states that E. K. Wittig and C. Hoffmann can be considered as the creators of the multi-cellular rotary-piston compressor. But it is only quite lately that this type of compressor came to be used in refrigerating machinery. He names in particular the four-cell rotary-piston compressor in the Coldspot refrigerator of the Sunbeam Electric Manufacturing Co., at Evansville, Ind. Among refrigerators using the compressor of the same type is the Majestic made by the Grigsby-Grunow Co. of Chicago. An eight-cell rotary-piston compressor was placed on the market at one time by the Stierlen Works at Rastatt. This is not manufactured any longer.

Reference is next made to the well-known multi-cellular rotary-piston compressor made by Sulzer Bros., Winterthur, and marketed under the names of Frigorotor and Frigocentrale. In connection with this compressor particular attention may be called to the matter of lubrication. The oil carried over to the condenser is there cooled by the cooling water and is returned to the compressor and its roller bearings under its own pressure. The oil that may get into the evaporator is picked up there by a jet apparatus together with the ammonia vapor coming from the evaporator and is delivered back to the suction side of the compressor.

In conclusion the author tells of tests of a multi-cell Frigorotor compressor which were carried out in the Experimental Laboratories of Sulzer Bros. Data of these tests are given in the form of an extensive table in the original article. (R. Plank and J. Kuprianoff, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 79, no. 12, Mar. 23, 1935, pp. 363–376, 33 figs.)

APPLIED MECHANICS

Motion of High-Pressure Powder Gases and Compression Waves in the Neighborhood of a Rifle Muzzle

BY MEANS of high-speed cinematography, the authors have studied some phenomena which occur in the neighborhood of the muzzle when the rifle is fired, such as the motion of powder gases and the propagation of compression waves.

The method of high-speed cinematography used in this study utilizes the illumination from high-frequency electric sparks as the light source of Schlieren photography. Several thousand pictures per second, with a time of exposure

less than half a microsecond, can be made.

The rifle used in the experiments was specially made; the bullet was 7.8 mm in diameter. The initial velocity of the bullets varied from 310 m per sec to 460 m per sec, according to the quantities of gunpowder used.

From the photographs taken it can be seen that there are, in general classification, five stages of the phenomena at the moment of firing:

(1) First there emerges a compression wave from the muzzle, which propagates nearly spherically. The mean ratio of the initial speed of the wave to that of the sound wave in air is 1.44. But as the wave proceeds about 70 cm from the muzzle the speed approaches that of the sound wave.

(2) At the same time as the compression wave appears a narrow jet issues from the muzzle at a high speed. The photographs show that this jet has a sort of periodical formation, the distances between each successive periodic pattern seeming to diminish as the jet proceeds. The relations between the distance of the jet from the muzzle and the time are shown in Figs. 7–12 in the original article, the origin of time being taken at the instant at which the rear of the bullet just appeared in front of the muzzle.

(3) When the front of the jet reaches some distance from the muzzle, the bullet comes out of the barrel and flies away with a nearly uniform velocity.

(4) Following the bullet, the high-pressure powder gases, which have propelled the bullet through the barrel, effuse into the atmosphere with a velocity exceeding the velocity of sound in air.

(5) An intense compression wave, caused by the violent effusion of the powder gases, propagates in every direction with a velocity of several hundred meters per second, which, after a few thousandths of a second, comes down to nearly the velocity of sound. The relations between the distance of the head of the compression wave from the muzzle and the time are shown in Figs. 22–27 in the original. The velocity of the wave front of this kind is nearly expressed in the form

$$V = V_T + V_0 e^{-\alpha t}$$

where V_T is the velocity of sound at temperature T, and α and V_0 are constants. The numerical values of these are given in a table in the original article, the units of length and time being centimeters and seconds respectively. (Kwan-ichi Terazawa, Mitsuo Tamano, and Sin-iti Hattori, Report of the Aeronautical Research Institute, Tokyo Imperial University, No. 117, January, 1935, illustrated, in Japanese, pp. 441–492, and English abstract, pp. 439–440)

Somewhat similar work was done some years ago by P. Quayle, since deceased, in the Acoustic Laboratory of the U. S. Bureau of Standards. Compare, among others, "Photography of Bullets in Flight," *Journal of the Franklin Institute*, 1922, vol. 193, pp. 627–640, and "Spark Photography and Its Application to Some Problems in Ballistics," *American Rifleman*, 1925, vol. 73, pp. 12–19.

BOILERS

Improvements in the Velox Boiler

ONE of the recent improvements in the Velox boiler consists in lodging the superheater elements inside of the evaporating elements. The lower portion of the latter element is purely an evaporating device, while the upper serves partly for evaporation and partly for superheating. In the new boiler the oil flame comes from above while the gases stream out of the combustion chamber from below, passing through the evaporating tubes and past the superheater tubes on their way to the upper collecting chamber. From there they travel to the gas turbine and then to the preheater lodged in the flue. Thus, a separate superheater housing is eliminated.

It is claimed that a Velox boiler acts as a momentary spare and may replace a steam accumulator entirely. In tests at Toulon, France, it was found possible to start up the Velox from the cold state and bring it to a full head of steam in 6 min 11 sec, and put it under full load in 1 min 20 sec more. (*The Brown Boveri Review*, vol. 22, no. 12, January-February, 1935, pp. 43–51, illustrated)

FUELS AND FIRING

Experience With Various Motor-Car Fuels as Compared With Gasoline

GERMAN experience has shown that when Diesel engines are used instead of gasoline engines there are savings in the cost of fuel of 8 pf. per km for buses and 13 pf. per km for trucks, not considering the interest and depreciation which is higher in the case of a Diesel engine because of higher first cost. This general problem, however, is entirely dependent on the tax on the importation of gasoline.

A portion of this article is devoted to the use of liquefied gases, in particular, propane and butane, which are recovered as by-products in the manufacture of synthetic gasoline. Because of this the available quantity of these gases is dependent on the amount of synthetic gasoline manufactured. The preliminary tests on the use of these gases as fuel for internal-combustion engines have been successful and a strong movement has been started to use these gases in motor vehicles as much as possible. These gases represent heavy hydrocarbons which are liquefied for purposes of storage and transportation and are usually handled in steel flasks. From two to three flasks are usually carried on a vehicle and connected with the motor by proper piping. As the liquefied gases in the flask are under pressure they must be preheated and expanded at the exit from the flasks. To do this the gases are led to the engine over a preheater and a pressure regulating valve. The ordinary carburetor is retained and only very simple changes need be made in the motor connections.

As the gas has a somewhat higher heat content than gasoline, its use does not lead to a reduction of output. On the contrary because of the complete absence of knocking, the motor runs more quietly and is more flexible than with gasoline. The employment of these gases as compared with gasoline also has the advantage that dilution of the lubricating oil is eliminated. Tests have shown that when butane is used (and in winter it should be mixed with propane, the congelation point of which lies lower than that of butane) there is a saving in fuel of about 20 per cent. The installation of flasks and additional equipment required costs from 350 to 400 rm in buses and less in trucks. The replacement of empty flasks by full ones is a very simple operation and takes only a couple of minutes. The tests carried out by the author have shown a consumption of 39 kg of liquid gas per 100 km as compared with 49 kg of monopolin (a German gasoline trade name) over the same distance. It would appear, therefore, that even if gasoline and butane and propane gas were sold at the same price there would be a material saving in the use of the latter.

The small flasks contain about 18 kg of gas and the large flasks about 40 kg. The weight of the flasks empty is approximately the same as that of their content. It is expected, however, that the weight of the flasks will be materially reduced. The pressure in the flasks which is normally at about 2 atm and rises to only 8 atm at a temperature of 40 C. If in the installation of the flasks care is taken that they are not exposed in the summer to direct sunshine and are

not located too close to the exhaust pipe, no very high temperatures and hence no very high pressures should develop in the flasks. At present, however, flasks are tested at a pressure in excess of 100 atm, and therefore the flasks are unnecessarily heavy. If it be assumed that a vehicle is supplied with three large flasks each containing 40 kg, this would correspond to the cruising radius produced by 200 liters of today's gasoline.

Among the advantages of the use of the liquefied gases is mentioned the fact that, unlike what happens in the case of the Diesel engine and wood-gas-producer motor, firing with liquefied gases can be substantially as in a standard gasoline engine. (Hermann Münz in *Verkehrstechnik*, vol. 16, no. 4, Feb. 14, 1935, pp. 88–90, 2 figs.)

Pulverized Coal Bulk Delivery to Users

TWO firms in England have now a service for the supply of pulverized coal, to customers who have no grinding equipment of their own. One of these is H. Tollemache and Co., Ltd., with a preparation plant at the Grimethorpe Colliery. The coal is sold under a guaranteed specification to conform to the following analysis: Volatiles, minimum, 35 per cent; ash, maximum, 4.5 per cent; moisture, maximum, 3 per cent; calorific value, 14,000 Btu per lb; fineness, 95 per cent through 100-mesh B.S. sieve.

It is stated that an average of the routine analyses of the last three months has shown the ash content to be only 2.8 per cent. The firm uses special railway tank wagons. They consist of two cylindrical containers mounted in a vertical position on a steel underframe. The containers are manufactured under a license from a German concern. There are no jets or agitators inside the body of the container.

The second firm having this kind of service is Rickett-Cockerell & Co. This firm is using special road vehicles for delivering the pulverized coal direct to the boiler house of the user. (*The Steam Engineer*, vol. 4, no. 6, March, 1935, pp. 236–237)

INTERNAL-COMBUSTION ENGINEERING

Witte 5- and 10-Hp Diesels

THESE are single-cylinder horizontal units provided with an open hopper for cooling. The fuel is handled by a Bosch pump and is injected horizontally into the cylinder combustion space. The fuel goes through a metal filter on the way to the injection pump which operates at a pressure of around 1500 lb per sq in. The engine is started by hand, means being provided for partially relieving the compression. The fuels to be used may vary in gravity 24 to 38 deg A.P.I.; such an oil contains sufficient lubrication for the injection pump. The fuel consumption is practically 0.44 lb per hp-hr. The 5-hp engine has a bore of $4^1/_4$ in. and a stroke of 6 in. with a rated speed of 850 rpm. The 10-hp Diesel has 5-in. bore and a stroke of 8 in. and operates at 720 rpm. (*Diesel Power*, vol. 13, no. 3, March, 1935, pp. 167–168, illustrated)

Combustion-Chamber Design

A NEW method of combustion-chamber design is said to have been developed in the Bohn Laboratories to control combustion. The principal design features involved with the new method are the location of the spark plugs, the effective length of the combustion chamber, the position of the intake valve, the rate of burning in relation to piston speed, and the compression ratio.

The location of the spark plug in the chamber is important in determining combustion time and although the exact location of the plug may vary in accordance with the desired results it has been found that practically satisfactory operation is obtained by positioning the spark plug approximately 70 per cent of the distance between the valve centers away from the intake valve and substantially on a line passing through the valve centers. The ideal filling characteristics and pressure rise per degree of crank travel are assured by predetermining the dimensions of the critical portions of the chamber from the cubic-inch displacement of the engine cylinder.

The throat area of the combustion chamber, or as it is often called the venturi, controls, to some extent, the flow of fuel mixture from the intake port to the cylinder. Accordingly, to obtain maximum volumetric efficiency, this area is proportioned from the area of the intake port or cubic-inch displacement of the bore. The designers have worked out a formula for the area of this throat; this formula is $A = D/C$, where A is the throat area of the chamber, D is the displacement of the cylinder, and C is a predetermined constant ranging from 17.5 to 18.5.

Other formulas have also been developed for the effective length of the combustion chamber and for areas at different portions of the chamber depending upon the general characteristics of the engine. The total volume of the chamber is determined by and dependent upon the particular compression ratio desired, and the volume of the combustion chamber over the bore is preferably between 30 to 35 per cent of the total volume, since it has been found that this percentage of volume over the cylinder bore provides proper control of the pressure rise per degree of crank angle.

Clearance of the combustion chamber around the intake valve is taken into consideration because of its effect upon the flow of the fuel mixture. The clearance varies in dependence upon the diameter of the intake valve and particularly satisfactory results have been found with a clearance which is approximately one-tenth of the valve diameter. The clearance around the exhaust valve is preferably slightly less than that around the intake valve, since in the usual engine construction the exhaust-valve port has a smaller diameter than the intake-valve port and the exhaust valve opens under pressure.

The method of calculation is shown in the original article. Compression ratios of from 6.3 to 6.5 have been found to be entirely satisfactory from a commercial standpoint, using standard 70-octane gasoline in a well-designed rigid engine. Recognition is also taken in the design system of the octane rating of the fuel. With fuel higher than 70 octane, for example, the effective length of the combustion chamber must be shorter to afford maximum combustion control, since this fuel will burn slower than the 70-octane fuel. Thus the combustion time of the effective length of the combustion chamber must be reduced in order to obtain, with the slower burning fuel, proper relationship between the points of maximum pressure and the top center position of the crank. On the other hand, with a more rapidly burning fuel the effective length must be greater. (*Power Plant Engineering*, vol. 39, no. 3, March, 1935, pp. 169–170)

Viscosity of Diesel Crankcase Oil

THREE factors are of interest in crankcase lubrication: (1) Reducing the wear of metallic parts; (2) reducing power absorption by the lubrication medium; and (3) obtaining a suitable lubricant.

The second factor is of minor importance in the lubrication of gasoline automotive engines but of importance in Diesel lubrication. After analyzing the relative advantages of light and heavy crankcase lubricants, the author finds that the oil-pump intake and feed lines are designed to handle a sufficient quantity of

the lubricant at normal operating temperature and oil viscosity. If the viscosity increases greatly the circulation will be considerably less. Oil circulation pumps are generally of the gear type, and it might appear that circulation would be improved when the oil being pumped has a high viscosity since leakage should be less. However, this leakage increases with the pressure against which the pump is operating, and D. P. Barnard has shown this pressure drop to be a direct function of absolute viscosity as indicated by Poiseuille's law. From a comparison of the relative viscosities of light and heavy lubricants at low temperatures given in the form of a table in the original article it would appear that with some oils difficulty would be experienced in supplying sufficient oil to the bearings under cold starting conditions. (John F. McGarry in *The Oil Weekly*, reprinted in *Diesel Engine Digest*, vol. 1, no. 12, March, 1935, pp. 10–11, illustrated)

LUBRICATION

Synthetic Lubricating Oils From Condensation Products of Ethylene

LUBRICATING oils have been produced by hydrogenation from bituminous-coal tars, but while they possess satisfactory viscosity they are not suitable for use because of their low-temperature suitability, high asphalt content, and tendency toward formation of new asphalt. Another method of producing lubricating oils from bituminous-coal tar consists in condensation of specific tar products by means of ethylene in the presence of aluminum chloride. Thus, for example, alkalization of naphthalene producing viscous oils has become the subject of many patents. Among these, C. Wulff shows that in order to produce this reaction, instead of anhydrous aluminum chloride, recoverable boron fluoride may be used though this latter does not act quite as powerfully in the way of condensation. In order to determine the structure and properties of such alloys tests were made with naphthalene, tetralin, and a bituminous-coal tar boiling at between 200 and 300 C. The details of these tests are described in the original article. The process used belongs to the class of high-pressure processes. The products obtained consisted of dark red-brown and green fluorescent oils containing some hydrogen chloride. The amounts recovered corresponded in the case of naphthalene and tetralin approximately to the theoretical amounts and were somewhat less in the case of bituminous-coal tar. In addition a viscous pitch-like material was found to be deposited on the walls of the autoclave. This was found to be a compound of aluminum chloride. The oils produced have been washed with alkali to make them acid-free, with water to make them alkali-free, then dried with calcium chloride, and by distillation freed of all constituents boiling below 200 C at atmospheric pressure.

The properties of three oils, two made from naphthalene and one from tar distillate, are given in the form of a table in the original article. From this it would appear that practically all the alloys produced from naphthalene come closely to the automobile-lubricant specifications. While the viscosity and ignition point of the tar lubricating oil is below standard, it is a light oil which can be produced so as to have the desired properties by means of a suitable fractionation. Its particular advantage lies in its very low temperature of congelation (—23 C). It is free from asphalt producers and shows no separation of solids even when cooled below the point of congelation.

The original article gives a set of curves showing the functional relationship between viscosity and temperature for various of these oils as compared with the viscosity-temperature curve of a Pennsylvania oil. Fraction No. 3 of a naphthalene-base oil shows practically the same shape as the Pennsylvania Oil. The remainder of the article deals with the effect of glow discharges on synthetic lubricating oils, showing that when applied they resulted in a material increase in viscosity which could be raised to any desired point and was dependent on the duration of the action. It was hoped that the glow-discharge effect might produce a flatter temperature-viscosity curve, but this has not yet been done. (Dr. H. Schildwächter in *Angewandte Chemie*, vol. 47, no. 39, Sept. 29, 1934, pp. 677–681, 5 figs.)

MACHINE PARTS

Planetary Speed Reducer

PLANETARY gears have been in use since a relatively early date. The essential advantage of the planetary gear, however, namely, uniform stressing of the components and compensation of lateral forces, was not realized in practice because, as a result of the various unavoidable small errors in pitch, tooth form, and eccentricity, the load was actually carried by a single gear. In the BHS-Stoeckicht speed changer this defect has been remedied by measures of design in a manner insuring uniform distribution of the load upon the planet gears, irrespective of whether the speed changer is of the spur- or bevel-gear type. As a result, the driving and driven shafts are relieved of deflection stresses and tooth pressures from the component gears, and the bearings are required to carry the weight of the rotating masses only. The casing also is not subject to any tooth pressures, with the exception of the circumferential force generated in the outer stationary ring gear.

This reducer can also be built with bevel gears. Compensation of the force in these gears is attained by the use of separate elements for guiding the gears and for the power transmission. The former is achieved by having the bevel wheels axially guided by hardened collars in the direct vicinity of the pitch circle. It is said that this mode of absorbing the thrust has given excellent results and, especially at high speeds, is greatly superior to carrying the gears in ball thrust bearings. The task of transmitting the power is given to a spider which is self-adjusting in the sense that it allows the planet gears to equalize the load between them. This is generally achieved by designing the spider so as to permit it to shift along the axis at right angle to the planet studs. The bevel-gear units are chiefly built as reversing gears for boats. In this capacity they allow of traveling astern for any distance and combine short length with practically noiseless running. A boat-reversing gear of that kind has been designed for 1000-hp at 1600 rpm. Its length is 23 in. and weight 485 lb. A number of such gears is said to be in use for special marine drives. (*Engineering Progress*, vol. 16, no. 2, February, 1935, pp. 51–52, 3 figs.)

POWER-PLANT ENGINEERING

Natural-Gas Drives Steam Turbines

MANUFACTURE of gasoline from natural gas presents an opportunity for appreciable reduction in power costs. This is particularly true where gas processed is at relatively high pressure, 400 lb for example, and a portion of the gas, free of gasoline fractions, is needed at low pressure for boiler fuel to generate process steam. It is possible to obtain the required fuel at the necessary low pressure by using a turbine as a reducing valve. Power developed by the turbine is then available for driving manufacturing pumps.

At the plant of Los Nietos Producing

& Refining Co., Kettleman Hills, Calif., this has been carried out. When treating 100,000,000 standard cu ft of wet gas per day at a pressure of 450 lb, 47,875 lb of steam an hour are required for pumping and process purposes. This is furnished from five 1500-sq ft horizontal return tubular boilers with water walls and superheaters. Steam is available at the turbine throttles at 145 lb pressure and 125 deg of superheat. When water, stabilizer, and shipping pumps are operated on gas, steam required for plant operation is reduced to 38,375 lb per hr, approximately a 20 per cent reduction.

When the manufacturers were approached regarding use of gas motive power for conventional steam turbines, they advised that it would be necessary to use 300-lb gas in place of 150-lb steam, and to double the number of nozzles and reversing chambers. This was done in one water-pump unit, but gas pressure was not raised above 185 lb. By actual trial, however, it was found that the extra nozzling was unnecessary.

After several months of continuous use, turbines operated on gas were opened and the runners inspected. No sign of erosion or corrosion were found. It was decided, however, to preheat the gas to about 200 deg in a steam preheater to insure against a possible "freeze-up" at the exhaust port. Operation of these conventional steam turbines on gas has been very successful. Test data from one unit are given in the table in the original article. (*Power*, vol. 79, no. 4, April, 1935, pp. 201)

Waste Heat From Furnace Gases

AT THE plant of Ley's Malleable Castings Co., Ltd., at Derby, England, the waste gases from the melting furnaces are used for steam generation, the steam being used to operate turbine-driven sets for supplying the power and lighting requirements of the works. The original installation consisted of a waste-heat boiler fitted to one of the melting furnaces and supplying steam to a 300-kw Allen turbo-generator set. Two additional boilers have since been installed together with two 1350-kw Metropolitan Vickers turbo-generators.

The original article describes in detail the handling of the fuel for the melting furnaces and the running of these furnaces. There are two melting furnaces to one waste-heat boiler and there are three boilers. The first boiler has no economizer or air heater, the temperature of the waste gases entering the boiler is approximately 2100 F, and the feed temperature of water supplied direct to the boiler is 200 F. A pulverized-coal burner is situated in the front wall of the boiler setting immediately above the entry of the waste gases and is used for boosting purposes when the furnace is being charged and the flue-gas temperature is low. Between the two melting furnaces there is a furnace chimney and at the top of it is installed a "pot lid" damper worked from the ground level by means of a hand winch. If the boiler is not in commission and either of the two melting furnaces is, then the damper is opened and the waste gases pass directly to the atmosphere, otherwise the damper is closed. If there is too much steam the damper can be partly "cracked" and the gases allowed to go to the atmosphere. The boiler has its own chimney. The details of the installation of the other two boilers are given in the original article. From the second boiler an evaporation of 17,000 lb has been obtained on waste heat only, and when working in conjunction with powdered fuel an evaporation of 22,000 lb of water per hr is expected. The second and third boilers are provided with Babcock & Wilcox tubular-type air heaters.

The turbines run at 5000 rpm and are coupled through double-helical single-reduction gears to the generators running at 1000 rpm. The turbines are of the high-pressure impulse type and comprise a velocity-compounded stage followed by seven single-impulse stages. A vertical-type governor controls the admission of steam to two groups of nozzles through the medium of an oil relay system. One nozzle group is proportioned to deal with loads up to 1080 kw; the second group automatically coming into operation to deal with loads up to the maximum rating of 1350 kw. A hand lever is, however, provided on the steam chest to permit the sequence of opening of the valves to be changed at will, and so enables the smaller group to open first for lighter loads, and by reducing throttling losses to obtain highly efficient operation at these loads.

An important characteristic of this type of plant is the forming of the top part of the condenser shell integral with the turbine exhaust casing, a construction which saves considerable head room and enables the plant to be accommodated on one floor level, and at the same time eliminates exhaust connection joints.

The condensers are of the two-flow type, and each has a cooling surface of 980 sq ft requiring 2100 gal of cooling water per min at 80 F.

Another feature of this type of plant is the direct drive from the turbine of both the circulating-water pump and the condensate extraction pump, the former being driven from an extension of the exciter shaft and the latter by gearing from the secondary gear shaft. The auxiliaries accordingly are able to run up to speed with the turbine, so facilitating starting and eliminating losses inseparable from the usual electrical drives.

Summarizing the results obtained by installing the waste-heat boilers and power equipment, the author states that the total amount of electricity generated during the past year would have cost the company approximately £12,000 if obtained from outside. The costs for generation by their own plant, after allowing 10 per cent for depreciation as well as interest on capital involved, amounts to $^1/_4$ d per unit. In addition to this factor, there are many other advantages accruing due to the heavy cost that would be incurred normally for heating the offices and foundries, etc., of a plant covering 40 acres. The use of preheated secondary air at a temperature of 470 F at the burners is another factor which must be taken into consideration. Against these obvious savings must be placed the charges made by the local electricity supply for a week-end load when the plant is shut down. This amounts to a heavy stand-by charge for the small week-end load of 250 hp. These charges are shortly to be eliminated by installing a Crossley gas engine for week-end loads, a 4-in. gas main already being available at the works. Under this scheme the costs for week-end running will be reduced to a negligible figure. (*The Steam Engineer*, vol. 4, no. 7, April, 1935, pp. 282–288, illustrated)

Development of Automatic Operation of Mechanical Stokers

THE article is mainly historical and the author points out that various conflicting factors, both human and mechanical, have influenced the evolution of the mechanical stokers since their earliest inception. Among other things he describes the suspended or "pendulum" clinker dam designed to be automatic in its action. It offers a predetermined resistance to the passage of material but will lift and release an accumulation of ash when the pressure exerted by it is sufficient to overcome the resistance. Where, however, the air supply to the various sections of the grate can be effectively sealed, the necessity for an accumulation of ash, clinker, and fuel at the rear end of the grate becomes of little or no importance.

Another European device to which

the author refers is the water-cooled clinker dam. (S. McEwen in *Engineering and Boiler House Review*, vol. 48, no. 4, October, 1934, pp. 234, 236, 238, and 240, 6 figs.)

Caustic Embrittlement in Boilers

THE author refers to previous investigations of the subject including the general survey of boiler accidents made by the Hartford Steam Boiler Inspection and Insurance Co. in 1897; investigation of scale formation at the University of Illinois at about the same time, and the second investigation at the same place in 1912; analysis of an explosion of a water-tube boiler in 1919 at Newmarket, Ontario; cracks in a vertical water-tube boiler in 1912 at Erie City, and finally the investigation of caustic embrittlement in Canada in 1931, as well as trouble in Ontario in a plant containing four Lancashire boilers.

Usually, the first indication of embrittlement is leaky joints that cannot be made tight in spite of repeated calking. As a rule, white deposits are frequently found at points where leakage occurs and on touching a particle to the tongue, soda ash can be tasted. In other cases a rivet head is found to have dropped off and, on hammering other rivet heads, it is found they also can be easily dislodged. On rivets being removed they, as well as the plates on the edges of the hole, are found coated with a black oxide and, whenever a condition of this kind is found, a careful investigation should be carried out to determine, if possible, the exact nature of the trouble. (The first instalment of a serial article by J. G. Graham, Boiler Inspection and Insurance Co., in *Modern Power and Engineering*, vol. 29, no. 2, February, 1935, pp. 20–21, and 34–35, illustrated)

RAILROAD ENGINEERING

New French Superheaters

A DISTINCTIVE feature of the Houlet annular superheater is the circulation of steam in a thin layer between two streams of hot gases, thus securing a rapid transfer of heat. The steam flows through an annular space between concentric tubes and returns through a smaller tube mounted inside the other tube. The difficulty of connecting the annular space to the header at one end and the return pipe at the other has been overcome by the use of welded joints.

These welded joints are so disposed that they are not subjected to bending. An important advantage claimed for the new superheater is that its substitution for other types, increases the superheat without reducing the steaming capacity of the boiler. A table in the original article shows by way of example that a $4^{15}/_{16} \times 5^{1}/_{4}$ in. flue can accommodate a Schmidt-type superheater element with a heating surface of about 1.31 sq ft per foot run, or an annular superheater element with a heating surface exceeding 1.97 sq ft per foot run with practically the same passage for gas flow in both cases. (*The Railway Gazette*, vol. 62, no. 8, Feb. 22, 1935, pp. 332–333, illustrated)

Manufacture of Superheater Units by a British Railway

THIS article deals with methods used at the Swindon Works of the Great Western Railway. The welding of the unit tubes to the return bends is now done on a flash-welding machine. The tube and bend butt together and are clamped by hydraulic cylinders fitted with two copper contact blocks. Upsetting pressure is produced by a spring and cam and the latter is changeable for dealing with unit tubes and $5^{1}/_{8}$ in. superheater flues. The internal scarf is removed by a dolly actuated by a hydraulic cylinder, while the tube remains clamped, immediately after welding. The external scarf is removed by grinding. The unit headers were previously made as castings but now take the form of drop stampings. The tubes are fixed in the headers by brazing. (*The Railway Gazette*, vol. 62, no. 8, Feb. 22, 1935, pp. 337, illustrated)

RESEARCH

Research in Fuels and Lubricants for Motor Cars

THIS article is based primarily on the work of the Paulsboro, N. J., laboratories of the Socony-Vacuum Oil Company. Until a satisfactory test machine is built for research in extreme-pressure lubricants the Socony-Vacuum Laboratory is continuing to use a special four-square hypoid gear machine described elsewhere in the article. A complete cycle of tests of one lubricant in this machine takes a full week of hard work. A separate test method has been developed to obtain information concerning the behavior of gear lubricants under subzero conditions.

Oiliness is the subject of another project in this laboratory. While the commonly available test equipment is being used little reliance is placed upon the findings until the results can be correlated with the performance in some suitable full-size equipment. The same lack of trust in laboratory tests is applied to the extreme-pressure research.

Among other things, it has been found that lubricants giving the lowest coefficient of friction do not necessarily give the least wear. In view of the special problems incident to the lubrication of aircraft engines, the laboratory is conducting a long series of tests on a single-cylinder air-cooled engine employing aviation-engine cylinders and an engine having high-temperature liquid cooling. One of the results of the work to date is the conclusion that certain oils cause ring gumming with great rapidity once a critical level of operating conditions has been exceeded. (Jos. Geschelin, Engineering Editor, *Automotive Industries*, vol. 72, no. 10, March 9, 1935, pp. 363–365, illustrated)

STEAM ENGINEERING

Tests on Back-Pressure and Bleeder Turbines

THESE tests were made on two AEG German turbines and are accompanied by a general discussion on the subject of back-pressure and bleeder turbines.

The large number of such turbines built by the AEG would indicate that their advantages have been well recognized and that the former distrust of gear reduction at high speeds has been overcome. It is also said that the gear-reduction turbine is also eminently suitable for handling larger amounts of steam where high-grade workmanship is desired. This is because this method of construction requires little space, can be built compactly, and has been successfully constructed for outputs up to 4000 kw. Larger bleeder turbines for sizes up to 25,000 kw and more are usually built with single or double housings and are of the multistage high-pressure type and operate at a speed of 3000 rpm. The large amounts of steam flowing through permit economical utilization of the steam either by way of bleeder construction or with a condenser. The high- and low-pressure parts of the turbines are usually so dimensioned as to produce the best efficiency for the conditions of operation most commonly encountered. Thus, for example, it often happens that the bleeder steam satisfies the major part of the power demand and only a small amount of condensation steam need be generated. In such a case it is proper to lay out the low-pressure unit and condensation system for only a comparatively small amount of steam. Should an extraordinary condition of operation occur where a large output of power with

TABLE 1 ACCEPTANCE TESTS OF A 10,000-KW. AEG BLEEDER TURBINE

Test No.	1	2	3
Date	April 19, 1934		
Output at busbars, kw	8746	10,044	5055
Cos φ	0.99	0.99	0.975
Speed, rpm	3300/1500	3300/1500	3300/1500
Total weight of steam, kg per hr	38,720	47,860	28,290
Extraction steam, kg per hr	.....	10,160	10,020
Condensate, kg per hr	38,720	37,700	18,270
Live-steam pressure, atm abs	33.9	34.3	34.5
Live-steam temperature, C	412.8	401.1	378.4
Extraction-steam pressure, atm abs	.....	3.05	3.04
Exhaust-steam pressure, atm abs	0.0787	0.0658	0.0404
Adiabatic fall of extraction steam, kcal per kg	.....	132.7	128.1
Adiabatic fall of condensed steam, kcal per kg	263.8	265.5	271.4
Theoretical output of extraction steam, kw	.....	1567	1493
Theoretical output of condensed steam, kw	11,880	11,630	5750
Total theoretical output, kw	11,880	13,197	7243
Efficiency at busbars, per cent	73.6	76.2	69.7
Generator efficiency, per cent	95.4	95.6	94.0[a]
Output at the connections, kw	9170	10.500	5380
Efficiency at connections, per cent	77.2	79.6	74.2
Losses in gearing, kw	130	130	130
Mechanical losses of the turbine, kw	80	80	80
Internal output of the turbine, kw	9380	10,710	5590
Internal efficiency, per cent	79.0	81.2	77.2

[a] According to data of the Siemens-Schuckert Works.

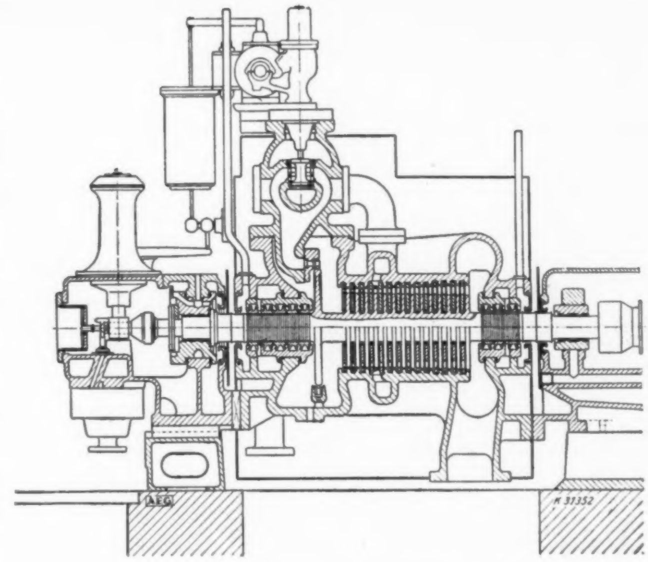


FIG. 7 LONGITUDINAL SECTION OF A 1000-KW 5600/1500-RPM AEG BACK-PRESSURE TURBINE

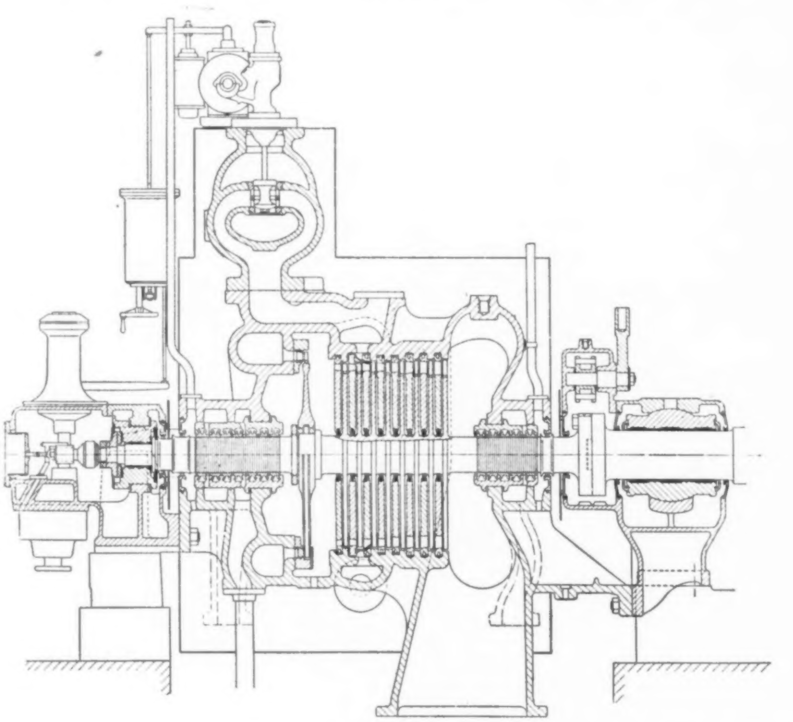


FIG. 6 LONGITUDINAL CROSS-SECTION OF A 5600-KW 3000-RPM AEG BACK PRESSURE TURBINE

a small amount of bleeder steam has to be generated, then the low-pressure unit should have a large overload capacity which is easy to provide with proper design. For this purpose and in order to decrease throttling losses the larger AEG bleeder turbines are provided with five high-pressure and four low-pressure nozzle valves.

Next is presented a discussion of the various types of turbines with their advantages. This is omitted because of lack of space.

In the tests themselves two turbines were used. The first was an AEG bleeder turbine with an output of 10,000 kw. It was ordered with a view to replacing an old condensing machine of about 8000 kw. As the generator already available ran at 1500 rpm, gearing was provided to reduce the turbine speed of 3300 rpm to that point. There has been no trouble in the operation of this gearing since 1933.

The turbine was laid out for a steam pressure of 34 atm gage, temperature of 410 C, 2.75 atm abs extraction pressure, and 93-94 per cent vacuum, and was placed in a single housing, notwithstanding the large number of stages. The high-pressure unit consists of a Curtiss wheel 1000 mm in diameter and seven single-wheel stages 800 mm in diameter.

The low-pressure units consist of one wheel 1300 mm. in diameter, and five wheels 1200 mm in diameter. In the first stage a bleeder station is provided for taking steam at a pressure of 12 to 16 atm absolute without governor control.

Recently the turbine has been rebuilt, with minor changes in governing, so that at either station 40,000 kg of steam per hr can be extracted. This shows how important it is for the purchaser of a turbine not to order the unit to niggardly dimensions, and to install, for reasons of economy, a machine, which, though satisfying immediate requirements, makes it impossible to meet a demand for more power if conditions of operation change without costly reconstruction of the machine.

The acceptance tests, Table 1, were carried out by the Dresden Electricity Works jointly with the Association for the Supervision of Steam Boilers, and have shown that the guarantees have been undercut by an average of 1.4 per

TABLE 2 ACCEPTANCE TESTS OF A 5600-KW AEG BACK-PRESSURE TURBINE AND A SIMILAR 1000-KW TURBINE

	Turbine 1			Turbine 2			
Number of test	1	2	3	1	2	3	4
Date of test	Oct. 31, 1933			Nov. 28, 1934		Nov. 27, 1934	
Output at busbar, kw	2393	3516	4785	751.2	892.0	1053.0	1294.0
Cos φ	0.67	0.80	0.91	0.825	0.83	0.783	0.816
Speed, rpm	3000	3000	3000	5600/1500	5600/1500	5600/1500	5600/1500
Live-steam pressure, atm abs	18.32	18.16	17.5	25.3	25.07	24.1	23.3
Live-steam temperature, C	316.2	316.0	315.9	375.0	374.0	379.7	374.5
Pressure in Stage I, atm abs	8.49	10.83	13.74	14.37	15.87	18.1	22.55
Back pressure, atm abs	3.53	3.53	3.58	5.98	6.01	6.05	6.13
Exhaust-steam temperature, C	168.6	158.4	154.5	235.3	231.1	238.0	239.4
Measured steam output, kg per hr	37,130	47,860	61,910	12,860	14,240	16,100	20,780
Steam consumption, kg per kwhr	15.51	13.6	12.93	17.14	15.97	15.28	16.05
Adiabatic fall, kcal per kg	85.7	85.3	83.2	84.6	83.8	82.8	79.7
Theoretical steam consumption, kg per kwhr	10.03	10.08	10.33	10.16	10.26	10.38	10.78
Efficiency at the busbar, per cent	64.7	74.1	79.9	59.4	64.3	68.0	67.2
Generator efficiency per cent	93.3	95.0	95.9	89.95[a]	91.2[a]	92.05[a]	93.05[a]
Efficiency at connection, per cent	69.4	78.0	83.4	66.0	70.5	73.8	72.2
Mechanical losses, kw	40	40	40	40	40	40	40
Internal efficiency, per cent	70.5	78.9	84.1	69.2	73.4	76.3	74.2

[a] According to measurements made at the testing laboratories of the Siemens-Schuckert Works.

cent. Extremely satisfactory efficiencies have been found, and in this connection attention is called to the fact that in the case of bleeder turbines the conditions are more difficult than in pure condensing turbines, because of the difference in the relative dimensions of the high- and low-pressure units.

The other unit tested was an AEG 5600-kg back-pressure turbine built for the Cellulose Works of Odermünde to operate with steam conditions of 17 atm gage, 350 C and 3.5 atm abs back pressure, and at a speed of 3000 rpm.

The steam passes through a single wheel governing stage of 900 mm and 10 impulse stages of 800 mm each. The most economical steam consumption was found to be at an output of 4900 kw. The measurements were carried out by the Stettin office of the Pomeranian Steam Boiler Inspection Association, and have indicated performance below guarantees of 0.5 per cent. An efficiency of 84.1 per cent was found for the point of the best steam consumption (internal efficiency calculated from the measurements of output). Fig. 6 shows a longitudinal section of a similar turbine installed at one of the works of the Community of Interests at an unnamed place. Table 2 records results of tests for turbine No. 2 also, which is an AEG back-pressure turbine with a nominal output of 1000 kw and a maximum output of 1300 kw.

This is shown in longitudinal section in Fig. 7. This machine has been installed to replace an older machine driving a low-pressure generator with an output of 1900 kva delivered at 520 volts and 15 rpm, which has been retained in service. This turbine was built for 24 atm gage, 350 C, and 6 atm abs back pressure, and consists of a single-wheel regulating stage 550 mm and 14 single-wheel stages 320 mm in diameter. The turbine runs at 5600 rpm and drives the generator at 1500 rpm through a gear reduction.

From measurements of output an internal efficiency of 76.3 per cent has been computed. With a modern generator of 1500 kva capacity, delivering 1000 kw with a cos $\varphi = 1$ and having an efficiency of 95 per cent, this turbine would give an efficiency of 70 per cent at the busbars.

The tests on the smaller turbines are of interest as showing that the difficulty of handling small amounts of steam can be overcome by the employment of the axial disk turbine. (Otto Rosenlöcher in *Elektrizitat im Bergbau*, vol. 10, no. 1, January, 1935, pp. 4–8, 3 figs.)

Turbine Blading

THE inventors say that experiments they have made on the blading of steam turbines show that the conditions of flow on the back of the blade are a matter of considerable importance, as regards the production of loss, and, in particular, it was found that the changes in the pressure on the backs of the blades must not exceed a given amount if the loss of energy in the blade passages is to be as small as possible. They consequently advocate that the cross-sectional areas of flow at the inlet and outlet of the blade passages be so dimensioned that the pressure at the inlet of each rotor blade passage is higher than the pressure at the outlet of such passage by about 2 to 10 per cent of the total pressure drop available for that stage. The cross-sectional area of the passage at the middle of the width of the blades should be 1.4 times greater than the outlet passage, and the line forming the inlet and outlet lips of the blade should intersect the center line at a point less than the width of the opening at the center of the passage. (British Patent No. 421,793, Sept. 13, 1934, Escher Wyss Maschinenfabriken Aktiengesellschaft, Zurich, Switzerland, in *The Engineer*, vol. 159, no. 4126, Feb. 8, 1935, p. 161)

WELDING

Oxy-Ferrolene Cutting and Welding

IN THIS process impregnated coal gas takes the place of acetylene, resulting, it is said, in very considerable economies as well as other advantages. The machinery has been built in England. In a typical plant installation the coal gas is delivered to a small electrically driven compressor which raises the pressure in the line to about 5 lb per sq in.

The gas then passes through a cleaner and from this into a cylinder which acts as a receiver to damp out pulsations and to give a steady gas flow. The impregnating material is a liquid and is introduced in the form of a jet into the gas, this rate being so arranged as to impregnate the gas to the desired point. The composition of the liquid is not stated.

It is said that the impregnation lowers the ignition point and retards the propagation of the flame resulting in an increase in cutting value and speed of cut, and also that the cut is narrower and the edges are not hardened. It is said that the Cleveland Motor Car Co., in America, installed ferrolene plants for such purposes as welding light-gage sheeting, and annealing steel body pressings. Coke-oven gas can be used instead of coal gas. (*Engineering*, vol. 139, no. 3602, Jan. 25, 1935, p. 99)

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following are records of the interpretations of this Committee formulated at the meeting of March 15, 1935, and approved by the Council.

CASE No. 798

(*Interpretation of Par. H-81*)

Inquiry: Par. H-81 of the Code refers to "unsupported joints" which are fusion-welded. Are the joints, when welded-in staybolts are attached to the plate as provided for in Par. H-83, considered "unsupported joints" as contemplated by Par. H-81, and do boilers fabricated in that way require shop inspection?

Reply: It is the opinion of the Committee that where staybolts in heating boilers are attached solely by welding the intent of Par. H-81 requires inspection by an authorized inspector during construction.

CASE No. 803

(*Interpretation of Par. P-214*)

Inquiry: Is it necessary, under the Code rules for staying of heads of firetube boilers, to apply stays to the segment of the head of an h.r.t. boiler when the maximum radial distance from the top row of the tubes to the shell, less the 2-in. exemption above the top row of tubes and less the exemption *d* next to the shell, does not exceed the allowable staybolt pitch of Table P-9 for the particular head thickness and working pressure?

Reply: Par. P-214 of the Code indicates the areas to be stayed when staying is required. The rules in Par. P-216 determine if staying is required.

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-186. Omit the last sentence of the last section which reads:

"Either method may, upon the request of a manufacturer who submits proper scientific data and evidence, be given a higher rating by the Boiler Code Committee than for forge welding, provided that an authorized inspector may demand a test of any one of the welded articles he may select for the purpose, and if, after witnessing such a test, he shall doubt the advisability of using the assigned rating for the weld, the case shall be referred to the Boiler Code Committee for its decision."

FIGS. U-11, U-15, AND U-17. To be revised to require $^1/_8$ in. to be machined off the fusion-cut surfaces instead of $^1/_4$ in. as called for by Fig. U-15, and $^1/_2$ in. as called for by Figs. U-11 and U-17. The words "flame-cut surfaces" to be used instead of "burned edges."

FIGS. U-10, P-2, and P-3. Corresponding changes to those proposed for Figs. U-11, U-15, and U-17 to be made in left-hand sketches of Figs. U-10 and P-2 and center sketch of Fig. P-3.

PAR. UA-19. Rewrite this paragraph to read:

UA-19. *a* The total bolt load W in pounds to be used in the design shall be determined by formula (1) below and shall be at least sufficient to resist the hydrostatic end force and to maintain a predetermined compression on the contact surface of the joint.

b The hydrostatic end force H in pounds is the total force exerted by the working pressure upon the area bounded by the outside diameter of the contact surface and is given by formula (2) below.

c The force H_G in pounds available to maintain the predetermined compression on the contact surface is the total force exerted by the unit compression acting upon the area of the contact surface and is given by formula (3) below.

d The unit compression on the contact surface should be some multiple of the working pressure such as experience has shown will be sufficient to maintain a tight joint, which multiple is known as the contact pressure ratio.[2] The available contact pressure ratio r shall be determined by formula (4) below.

$$W = A_B \times S_B \quad \text{(1)}$$

$$H = P \times A_P \quad \text{(2)}$$

$$H_G = W - H \quad \text{(3)}$$

$$r = \frac{H_G}{P \times A_G} \quad \text{(4)}$$

W = total bolt load, lb
A_B = total cross-sectional area of the bolts at the root of the thread or place of least diameter under stress, sq in.
S_B = maximum allowable unit working stress in the bolts, as given in Table UA-1, lb per sq in.
H = total hydrostatic end force, lb
P = maximum allowable working pressure, lb per sq in.
H_G = total gasket or contact load, lb
A_P = area bounded by the outside diameter of the contact surface, sq in.
A_G = area of the contact surface, sq in.
r = contact pressure ratio.

[2] The ratio of the unit compression on the contact surface to the working pressure (known as the contact-pressure ratio) depends upon the material and shape of gasket or ground face, the form of raised face or gasket groove, the nature of the confined fluid, and other similar considerations.

PAR. UA-20*b*. Change the definitions of H_G and W to read:

H_G = total gasket or contact load as defined in Par. UA-19, lb

W = total bolt load as defined in Par. UA-19, lb

PAR. UA-21*a*. Change the definitions of W, B, g, and b to read:

W = total bolt load as defined in Par. UA-19, lb

B = for flanges without hubs, the inside diameter of flange, in.

= for hubbed or integral flanges, the average mean diameter of hub, in.

= inside diameter of hub plus g (see Fig. UA-5)

g = average of the hub thickness over the distance from the back of the flange to the end of the effective hub height, in. (see Fig. UA-5). For hubbed flanges with circular fillets larger than required by Par. UA-21*c*, the fillet may be considered equivalent to a 45-deg taper on the hub tangent to the circle.

b = for loose or screwed flanges or hubbed flanges attached by means of a lap joint, the distance measured from the middle of flange thickness (t) to end of hub, in.

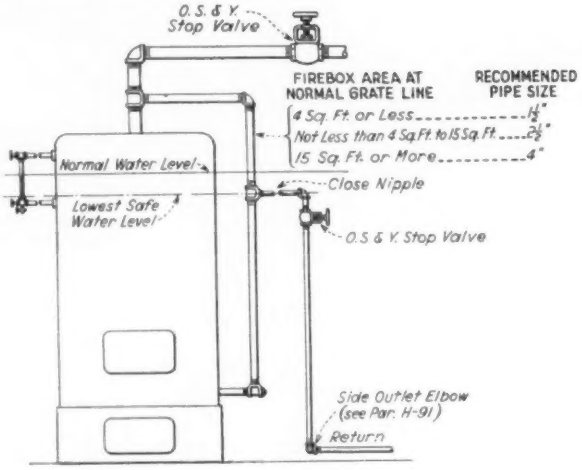
= for flanges integral with the shell or fusion-welded thereto as shown in Fig. UA-2*d* or hubbed flanges fusion butt-welded thereto as shown in Fig. UA-2*e*, the effective height of hub = $\sqrt{B_0 g_0}$ measured along the shell from middle of flange thickness (t), in., (See Fig. UA-5).

PAR. UA-21*a*. Add two new definitions as follows:

B_0 = mean diameter of hub at junction of flange and hub = inside diameter of hub plus g_0, in.

g_0 = thickness of hub at junction of flange and hub, exclusive of fillet required by Par. UA-21*c*, in.

Figs. H-3 and H-7 revised:



PAR. UA-22*d*. Revise as follows:

d Hubbed flanges may be fusion butt-welded to the end of a vessel or pipe as shown in Fig. UA-2*e* and considered as an integral flange, provided that:

(1) the distance from the back of the flange to the center line of the weld is at least:

(*a*) For vessels or pipes less than 1 in. thick: 3 times the thickness of the vessel or pipe, but not less than 1 in.

(*b*) For vessels or pipes 1 in. or thicker: 3 in.

(2) The hub of the flange at the beginning of welding edge shall have the same outside diameter and thickness as the shell or pipe to which it is to be butt-welded. The outside of the hub shall be either straight (parallel to the inside of the vessel or pipe), or tapered at not more than 6 deg, for a distance measured from the beginning of the welding edge at least one-half of the distance specified in (1) above.

LETTERS AND COMMENT

Solid Smokeless Fuel

TO THE EDITOR:

The paper[1] by Messrs. Jacobsen and Carter presents valuable information on the mechanism of heat transfer between superheated steam and coal. In addition the experiments furnish a basis for the design of larger and greater carbonization retorts.

The paper is of particular interest to the smoke-abatement engineer, because his greatest problem at the present time is the elimination of smoke from residences, cook stoves, and small apartment-house heating plants.

The solution is not easy. Furnaces and boilers can be equipped with stokers or converted to other fuels. The process is a slow one, and unless encouraged by a vigorous smoke-abatement department, many owners will consider themselves financially incapable of making the improvement.

Heating stoves and similar equipment cannot be converted to other fuels, nor is it possible to equip them with stokers. Any improvement made must be in the nature of new equipment involving considerable expense. In general, the financial resources of those who live in houses heated by stoves, is limited. Hence, not much improvement can be expected along this line.

There are two possible solutions for the heating stove: (*a*) Development of new fool-proof and smoke-proof equipment, and (*b*) the use of a solid smokeless fuel in the present equipment.

The first method involves a tremendous program of experimentation, the design and testing of new equipment, the manufacture and marketing of the new product.

It is my belief that the most reasonable solution lies in the production of a solid smokeless fuel. Except in rare instances, present equipment does not need to be changed to burn the smokeless fuel successfully. Acceptance of the smokeless fuel by the consumer has been gratifying. However, the test has been conducted on a very small scale only, and may not be indicative of average consumer response.

The cost of the fuel is important. It should not greatly exceed that of lump coal. From Messrs. Carter and Jacobsen's report it may be concluded that intelligent retort design and application of the data presented will result in small production costs, thus permitting the smokeless fuel to be sold at or near the present cost of lump coal.

J. BILLITER.[2]

[1] MECHANICAL ENGINEERING, May, 1935, pp. 305–308.

[2] Assistant Engineer, Engineering Department, Salt Lake City Corporation, Salt Lake City, Utah. Jun. A.S.M.E.

The Master Science

TO THE EDITOR:

It was an engineer with time on his hands in one of the depressions of the past, who became interested in fundamental problems and wrote "The Principles of Sociology"—often called the the master science.

Herbert Spencer, about two generations ago, wrote this classic work and also the outstanding paper "The Social Organism," which made quite a stir about 1860. A bit later Thomas Huxley, biologist, also groping for fundamentals in ethics,

and seeking to interpret human development in terms of the Darwinian generalizations, tried his hand at sociology in 1893.

Since that time many observers in the field of societal investigations have been busy at work in the field of human relations and social evolution, forcing the conviction that the basic problem of today is sociological, not technological nor economic.

Spencer and Huxley sought a foundation for ethics other than supernatural sanction, and raised questions that have not received a complete answer to this day. Education—popular education—was at one time supposed to offer possibilities of a solution of our social difficulties. It was supposed that "if everybody was educated" the millenium would soon be achieved. A bit later, came the idea that technical education would speed and increase production and bring the happy days. Then the study of economics was appealed to, as a sort of court of last resort which would adjust and quiet the troubles of the world.

But probably, as with engineer Spencer, a deeper study of the problem will bring us to the portals of the master science, sociology.

Whether or not there is within the brief space of recorded human history even a slight evidence of biological evolution, there does seem a tendency at the present time for more commercial organization, whether we like it or not. The emphasis for control of surplus (capital), is in the interests, not of the individual, but of the social group.

Henry Adams in his story "The Education of Henry Adams" tells us of the changes and transformation in our social order from the day when his grandfather was president and seems to feel that a broader control of societal surplus is inevitable.

Like Herbert Spencer, many engineers today find themselves the victims of technological unemployment, and may interest themselves in social studies to advantage and align themselves with this trend as it may make itself evident.

The lesson of sociology is that control tends to be, and should be, in the hands of the competent—those societally competent. The lesson for engineers is to try to be societally competent in the broadest possible way.

There are three degrees for the engineer really.

First, the apprentice degree, the technological.

Second, the fellow-crafts degree, the economic.

And finally, the master-engineer degree for those who understand human relations and development and the secrets of the master science—sociology.

David H. Ray.[3]

[3] Los Angeles, Calif. Life Mem. A.S.M.E.

REVIEWS OF BOOKS

The Flexible Budget

The Flexible Budget. By John H. Williams. McGraw-Hill Book Company, New York, 1934. Cloth, $5^1/_2 \times 8$ in., 288 pp., $2.50.

Reviewed by Walter Rautenstrauch[1]

The author has set forth in this little volume a much needed exposition of the principles and practices of budget making. It is not generally realized that the expenses of operating a business vary in determinable proportions to the volume of sales. The author points out ways in which the fixed and variable costs of a business may be assembled in relation to the volume of sales in a manner which will enable the executive to forecast with a reasonable degree of probability what the details of the expense items should be at varying outputs.

After discussing the budget and its scope, the author shows the need for fixing definite responsibility on particular individuals for the expenditure to be made. With this responsibility fixed, procedure in organization and classification of budget material is discussed. The division of this material into constant and variable costs is discussed under the title "Flexibility" from which the book derives its name. The author quite properly calls attention to the fact that a knowledge of the details of operating procedure is essential for the identification of cause and effect in the expenditure of funds. The master budget and the operating budget, their preparation and use, are clearly set forth. The book is much enhanced in value by a discussion of unusual conditions to be met. It is realized that the budget is merely a forecast of probability of expense under certain assumed conditions of operation. Variations of these conditions must necessarily be reflected in actual expenses as compared to budget expenses.

The book not only discusses principles of budget making but is illuminated by the experience of the author in his own professional practice. It is a good common-sense statement of the problems involved in budget making and the results to be expected. A copy of the book should be on the desk of the executive responsible for the preparation of the budget and the operation of the business in accordance therewith.

[1] Professor of Industrial Engineering, Columbia University, New York, N. Y. Mem. A.S.M.E.

Books Received in Library

A.S.T.M. Standards on Refractory Materials. Prepared by Committee C-8 on Refractories, American Society for Testing Materials, Philadelphia, February 1935. Paper, 6×9 in., 143 pp., illus., diagrams, charts, tables, $1. This volume brings the publications of the Society upon refractory materials together in convenient form. The book contains the specifications for refractories, the standard methods of testing them, and the formulas for standard samples of refractory materials which the Society has approved. It also contains the manual for the interpretation of tests, the standard definitions, and surveys of the conditions under which refractories are used in open-hearth practice, in by-product coking, and in the malleable-iron, copper, and lead industries.

Atomic Structure and Spectral Lines. Vol. 1. By A. Sommerfeld, translated from the fifth German edition by H. L. Brose. E. P. Dutton & Co., New York, 1934. Cloth, 6×9 in., 675 pp., illus., diagrams, charts, tables, $10.80. The rapid progress of atomic physics during the past decade has caused Professor Sommerfeld to prepare a new edition of this classic treatise, in which the material has been rewritten and rearranged in conformity with modern theories. The new edition will appear in two volumes, of which the present contains the older quantum theory and is in part an abbreviation and in part an extension of the fourth German edition. The second volume will be an elaboration of his former book on "Wave Mechanics." The book is one of the great works on the subject and the new edition will be most valuable to all interested in atomic physics.

Chemical Formulary, Vol. 2. Edited by H. Bennett. D. Van Nostrand Co., New York, 1934. Cloth, 6×9 in., 570 pp., $6. A useful collection of recipes for making lubricants, paints and lacquers, plastics, cosmetics, etc., and for polishing, cleaning, and plating metals and other materials. Several thousand recipes are given, selected from many sources and grouped under general heads. The volume supplements volume one of the work and brings it up to date.

(Continued on page 400)

Highlights of the CINCINNATI MEETING

Transportation Arrangements to Cincinnati, Ohio, and Norris Dam

ON THE following pages will be found the programs of the Semi-Annual Meeting of The American Society of Mechanical Engineers (p. 391), to be held at Cincinnati, Ohio, June 17 to 21, with headquarters at the Hotel Gibson, and the National Meeting of the A.S.M.E. Applied Mechanics Division (p. 395), at Ann Arbor, Mich., June 18 and 19. It will be noted that while these meetings are held simultaneously, the technical program of the meeting in Cincinnati does not start until Wednesday, June 19. Hence members who wish to attend both meetings will find that the overlapping of programs is confined to a single day.

Attention is also called to the inspection of the Norris Dam, in cooperation with the Tennessee Valley Authority, and the meeting at Norris City, Tennessee, under the auspices of the Knoxville Section, A.S.M.E., on Saturday, June 22. The Society for the Promotion of Engineering Education will take part in the meeting at Norris City, which has been scheduled for the convenience of members en route to the Forty-Third Annual Meeting of the S.P.E.E. at Atlanta, Ga., June 24 to 27.

REDUCED RAILWAY FARE ON ROUND-TRIP TICKETS

Reduced railway fares on round-trip tickets are available for the Cincinnati meeting. The "identification certificate" plan will be used. Every member of the Society will receive through the mail an identification certificate. If this certificate has not been received, write to Society headquarters for one, as local ticket agents are not supplied with certificates. The certificate must be presented to the ticket agent at the time the "going" transportation is purchased. The certificate is good for the member and all of his family. To get the benefit of the reduced fare, which is one and one-third times the regular one-way fare, a round-trip railroad ticket must be purchased.

Arrangements should be made with the ticket agent for the desired route, going and returning. The return trip may be made via the going or any other authorized route. The railroad ticket itself must be validated at Cincinnati, or at Knoxville if the post-convention tour to Norris Dam is included, before it can be used on the return trip.

SPECIAL TRAIN FROM EAST

For members from the East arrangements have been made for a special de luxe Pullman train with dining-car service leaving Pennsylvania Station, New York, at 3:55 p.m. (EST), Philadelphia at 5:26 p.m., and Washington at 4:20 p.m., on Tuesday, June 18. This train will stop at principal points en route and will arrive at Cincinnati at 8:15 a.m., on June 19. A sleeping car will be added at Pittsburgh, open for occupancy at 9:30 p.m.

TRANSPORTATION TO NORRIS DAM

Members taking the trip to Norris Dam should indicate Knoxville, via Cincinnati, as their destination. The train will leave Cincinnati at 8:45 a.m. Saturday, June 22, and arrive at Coal Creek at 2:33 p.m. Here the party will be transferred by automobile to Norris Dam. The party will leave Norris Dam for Knoxville, Tenn., at 8:30 p.m., where those returning to the East will take a train on the Southern Railway at 9:10 p.m. This train is due to arrive in New York on Sunday at 4:15 p.m.

TRANSPORTATION FROM OTHER POINTS

Members from Central, Mid-West, and Western points should purchase their railroad tickets with Knoxville, Tenn., as destination point, providing they are planning to visit Norris Dam; otherwise Cincinnati should be the designated destination. From certain points in the far West, summer tourist tickets may be cheaper than the fare and one-third rate of the certificate plan. It is therefore recommended that members consult with their local ticket agents.

Members from the South and Southeast should designate Cincinnati as their destination.

PROGRAM AT CINCINNATI

Registration for the Cincinnati Meeting will open at the headquarters, Hotel Gibson, 2 p.m., Tuesday, June 18. On Tuesday morning the Council will convene at 9:30 o'clock. The Business Meeting is scheduled for Wednesday afternoon at 4 p.m. The Nominating Committee will start its sessions at 10:30 a.m. on Wednesday in the Grecian Room, where those who wish to appear before the committee on behalf of candidates may do so.

A study of the technical program, reproduced on the following pages, will reveal the emphasis that has been placed on problems of production, machine and shop operation, and power. A symposium on prefabricated housing is of timely interest; and the sessions of the Graphic Arts Division, devoted to color, color printing, and other problems of the division, will attract many members.

Especially significant and instructive will be the Calvin W. Rice Memorial Lecture, to be delivered by Adolph Meyer, managing director and chief engineer of Brown, Boveri and Company, Baden, Switzerland, on Thursday at 4:15 p.m. Mr. Meyer will talk on the Velox steam generator, a recent notable product of the company with which he is associated.

Mayor Wilson will speak at the Wednesday luncheon. Clarence A. Dykstra, City Manager of Cincinnati, will address the Thursday luncheon at the Netherlands-Plaza Hotel.

On Thursday evening at 6:30, an opportunity will be provided for members and guests to hear President Flanders, who will be the principal speaker at the dinner arranged for that meeting.

Another noteworthy feature of the dinner will be the presentation of the Holley Medal for 1934 to Irving Langmuir, for contributions to science and engineering, especially in the development of gas-filled incandescent lamps, of the thoriated filament for thermionic emission, of atomic-hydrogen welding, of phase-control operation of the thyratron tube, and of research in oil films.

Excursions to points of interest and plants in the vicinity of Cincinnati are being planned by the local committee. Complete details will be available at the meeting.

PROGRAM AT NORRIS DAM

At Norris Dam on Saturday, June 22, members of the A.S.M.E. and guests will meet with members of the Knoxville Section and the S.P.E.E. at 4 p.m. in the Recreation Hall Auditorium, where a TVA sound film on developments by the Tennessee Valley Authority will be shown. This will be followed at 5 p.m. by an address by one of the directors of the TVA and a dinner at 6 p.m. in the Norris Cafeteria. At 7 p.m. guides will conduct the visitors on a tour of inspection of the dam, the quarries, and Norris City.

Program of

A.S.M.E. SEMI-ANNUAL MEETING

Cincinnati, Ohio, June 17-21, 1935

(Unless otherwise stated all events will be held at the Gibson Hotel, Headquarters for the Meeting)

MONDAY, JUNE 17

10:00 a.m. Committee on Local Sections **Old English Room**

TUESDAY, JUNE 18

9:30 a.m. Council Meeting **Tenth Floor**

2:00 p.m. Registration opens **Ballroom Floor**

(Registration fee of one dollar for each non-member)

WEDNESDAY, JUNE 19

10:30 a.m. Nominating Committee Open Meeting **Grecian Room**

9:30 a.m. **Materials Handling** **Ballroom**

Chairman: C. L. Koehler *Recorder:* Frank H. Pfefferle

1—Overhead Chain-Driven Trolley Conveyers as Used in the Automotive Industry, by J. B. Webb and N. H. Preble, Jervis B. Webb Co.

Uses in handling chassis, frames, work in machine shop, sub-assemblies, stampings, body work, upholstery, finishing, painting, and special processes. Illustrated by slides and films.

2—Conveyer Systems, by M. J. Anderson, Mathews Conveyer Co.

Variations and complications in design of conveyer systems, including brief outline of systems in steel plants, rubber plants, and breweries, and in vegetable handling. Illustrated by slides.

9:30 a.m. **Education and Training** **Parlors Q, R, S**

Chairman: George A. Seyler *Recorder:* P. K. Johnston

1—Backgrounds of the Cooperative System, by Herman Schneider, University of Cincinnati

An estimate, by its originator, after thirty years' experience, of the five-year cooperative college engineering course in which students' time is divided into alternative periods of student work in college and in industry.

2—National Apprenticeship Under Way, by William F. Patterson, Federal Commission on Apprentice Training

Federal-State apprentice-training program based on self-government of industry provides for broad training related to general and technical education and recognizes that in the beginning apprentices must be paid less than unskilled workers.

3—Apprenticeship Training—Personnel, Methods, and Materials, by J. F. Kolb, National Metal Trades Association

Four-year well-rounded program of training in fundamental operations with special job training in fourth year and the development of manuals used for instructions.

9:30 a.m. **Prefabricated Housing** **Roof Garden**

(Auspices of Wood Industries Division)

Chairman: G. R. Petrie *Recorder:* Arthur H. Morse

1—Plywood and Prefabricated Plywood House Units, by Thomas D. Perry, Jasper Wood Products Co.

Standardized factory sub-assembly of hollow plywood wall and floor units; field erection of houses possessing ample strength and insulation factors; opportunities for artistic treatment at reduced construction cost.

2—New Method of Construction for Prefabricated Houses, by Charles B. Norris, Haskelite Manufacturing Co.

Difficulties of properly fastening light steel framework; new method of construction eliminates such fastenings and substitutes panels covered with plywood that carry the load and are stiffened by steel; methods and formulas for strength computations.

3—Mechanical Units for Houses, by D. C. Slipher, Houses, Inc.

4—Financial Aspects of Housing, by Ross Tucker, Massachusetts Institute of Technology

Housing for three income groups; middle-income group (under $3000 per year) constitutes new market that can be served if properly approached; housing lower income group requires subsidy.

9:30 a.m. **Hydraulic** **Parlors A, B, C**

Chairman: C. F. Merriam *Recorder:* Earle W. Vinnedge

1—Construction of 115,000-Hp Turbines for Boulder Dam Power House, by W. M. White, Allis Chalmers Mfg. Co.

Design and construction of high-head units including an outline of testing and development work and the special procedure required in construction.

2—The Dnieprostroy Turbines, by R. V. Terry and D. C. Moorhead, Newport News Shipbuilding & Drydock Co.

Design, fabrication, erection, and operation of nine hydraulic turbines for U.S.S.R.

3—Design of Largest Propeller-Type Unit for Wheeler Dam, by F. H. Rogers and R. E. B. Sharp, Baldwin-Southwark Corp.

Engineering problems in design of largest propeller-type unit as yet constructed in this country; description of homologous model unit, including draft tube, casing, intake, and racks.

9:30 a.m. **Drying** **Old English Room**

(Auspices of Process Industries Division)

Chairman: W. K. McAfee *Recorder:* Walter E. M. Fielman

1—Drying of Ceramic Products, by J. L. Carruthers, Ohio State University

Problems in designing, operating, and improving ceramic-drying processes, including economical drying rates, the elimination of defective ware, and ordinary variables of drying system.

2—Recommended Practice on Testing Drying Equipment

12:00 m. Luncheon **Mezzanine**

Address by Russell Wilson, Mayor of Cincinnati, with response by President Flanders

2:00 p.m. **Waste Elimination** **Parlors A, B, C**

(*Auspices of Management Division*)

Chairman: C. B. Auel *Recorder:* E. B. Royer

1—Prevention of Waste and Reclamation of Materials, by J. Q. Salisbury, National Cash Register Co.

Operation of National Cash Register plan for the prevention of waste; examples of reclamation of materials.

2—Salvaging and Reclaiming Items in Every-Day Use, by Thomas H. Owens, Westinghouse Elec. & Mfg. Co.

Methods used by Westinghouse Elec. & Mfg. Co. Data supplements material submitted by company to the "Waste Materials Dictionary," published by A.S.M.E. in 1931.

2:00 p.m. **Prefabricated Housing** **Roof Garden**

(*Auspices of Wood Industries Division*)

Chairman: G. R. Petrie *Recorder:* R. E. Broderick

2:00 p.m. **Railroad-Machine Shop** **Parlors Q, R, S**

(*Auspices of Railroad and Machine Shop Practice Divisions*)

Chairman: W. H. Winterrowd *Recorder:* C. R. Chalkley

1—How Can Railroad Shops Justify the Use of Modern Machine Tools and Methods, by A. Sellers, Jr., Sellers Machine Tool Co.

Locomotive maintenance methods; cost of railroad maintenance and how it is broken down; comparison with factory maintenance costs; need for cost yardstick.

2—Railway Equipment Maintenance, by L. D. Freeman

Timeliness of well-planned program of rehabilitation; cost of locomotive repairs every 4.29 years equals original purchase price; average age of all shops 21 years and of machines 21.6 years; both generally inadequate to maintain large modern units of equipment economically.

2:00 p.m. **Materials Handling** **Ballroom**

(*Auspices of Materials Handling Division*)

Chairman: E. D. Smith *Recorder:* Frank H. Pfefferle

1—Applications of Electric Industrial Trucks in Industry, by S. W. Gibb, Yale & Towne Manufacturing Co.

Application of fork trucks and pallets as used in handling miscellaneous products and cargoes on waterfront in steel, automotive, metal-working, ceramic, paper, food, and tinplate industries. Illustrated with slides and motion pictures.

2—Bulk Handling, by E. J. Burnell, Link Belt Co.

Recently designed equipment for preparation and handling of earth, sand, gravel, stone, coal, coke, ore, and sewage. Illustrated by slides.

4:00 p.m. Business Meeting **Ballroom**

6:30 p.m. Informal get-together dinner **Summer Garden**

THURSDAY JUNE, 20

9:30 a.m. **Steam Power** **Roof Garden Foyer**

Chairman: A. A. Potter *Recorder:* Otto E. Hilmer

1—Division of Load Among Generating Units for Medium Costs, by J. E. Mulligan, Massachusetts Institute of Technology

Criteria for such division are shown to depend on forms of input-output curves, characteristics of which are discussed.

2—Leakage of Steam Through Labyrinth Seals, by A. Egli, Westinghouse Elec. & Mfg. Co.

Rational theoretical treatment, based on actual flow characteristics typical for sharp-edged orifice; relations of leakage, throttlings, and pressure distribution given in graphical form intended for use in practical turbine design.

3—Steam-Turbine Leaving Losses and Vacuum Corrections, by Linn Helander, Kansas State College

Procedure, primarily for power engineers, wherein steam-turbine vacuum corrections may be calculated when design characteristics of last row of blades and one set of water rates for specified steam conditions and loads are known.

9:30 a.m. **Quality Control** **Parlors Q, R, S**

(*Auspices of Management Division*)

Chairman: M. F. Skinker *Recorder:* Martin E. Rollman

1—Quality Control in Manufacturing, by J. F. Feely, Western Electric Co.

Western Electric set-up for quality control; practical limitations in routine inspection; use of inspection records; examples of results. Paper will be followed by discussions on Recording Systems, Statistical Control, and Inspection, by W. G. Wiggins, A. Juran, and H. F. Dodge.

2—Effective Handling of Quality Complaints, by Harry Benson, Cheney Brothers

Methods of quality control as applied in large textile concern engaged in manufacture of diversified line of fabrics employing silk, rayon, cotton, and wool, to produce upholstery, dress velvets, broad silks, knitting yarns.

9:30 a.m. **Materials Handling** **Old English Room**

Chairman: J. A. Jackson *Recorder:* E. A. Oster

1—Handling Concrete by Pipe, by C. F. Ball, Chain Belt Co.

Pumping concrete through 7-in. pipe line 1000 ft horizontally, and 120 ft vertically at Boulder Dam. Illustrated by motion pictures.

2—Synchronizing of Conveyers, by A. J. Schenk and R. K. Wilson, Alvey Ferguson Co.

Synchronization of conveyer units in systems; description of automatic loading, unloading, and transfer devices; comparisons of mechanical and electrical synchronization.

9:30 a.m. **Lubrication Engineering** **Parlors A, B, C**

(*Auspices of Machine Shop Practice Division*)

Chairman: Forrest Cardullo *Recorder:* Carlton Brown

1—A Lubrication Program for an Industrial Plant—Its Functions and Problems, by V. M. Palmer and Horace Smith, Eastman Kodak Co.

Lubricating practices in Eastman plants; methods of selecting, testing, and applying lubricants; savings effected.

2—Loading and Friction of Thrust and Journal Bearings With Perfect Lubrication, by H. A. S. Howarth, Kingsbury Machine Works, Inc.

Formulas and charts for use in bearing design, from previously published works with new material added for completeness.

9:30 a.m. **Lectures on Color** **Roof Garden**

(*Auspices of Graphic Arts Division and Graphic Arts Research Bureau*)

Chairman: A. C. Jewett *Recorder:* H. A. Merten

1—Color Chemistry, by A. E. Gessler

Illustrated by exhibits of latest chemical developments in color; facts on chemistry of color and colors not easily available; progress effected in producing non-fading, alkali-proof, permanent colors for packages, general printing, and paints.

11:00 a.m.

2—Color as Light, by C. Hardy

Color measurement and specifications; instrument using photoelectric cell by means of which curve of color may be traced to reveal characteristics of aid in selecting proper color, in specifying color, and in predicting its behavior in mixtures, or, for example, in the three-color printing.

12:15 p.m. Luncheon **Netherlands Plaza Hotel Pavillion Caprice**

Speaker: City Manager Clarence A. Dykstra

2:15 p.m. Steam Power Roof Garden Foyer

Chairman: D. S. Brown *Recorder:* Edward H. Mitsch

1—Principles Underlying the Rational Solution of Automatic-Control Problems, by S. D. Mitereff

Presents twelve fundamental equations governing characteristics of automatic regulators; six cover all present forms of commercial regulators, and the remainder cover modifications and improvements to increase accuracy and flexibility.

2—Application of the Elastic-Point Theory to Piping Stress Calculations, by S. W. Spielvogel, Brooklyn Edison Co., and S. Kameros, New York Edison Co.

Application of neutral-point theory to piping expansion problems leads to simplification in their solution; formula eliminates laborious steps in computations and simplifies procedure into the determination of two moments of inertia.

3—Rolling-in of Boiler Tubes, by F. F. Fisher and E. T. Cope, Detroit Edison Co.

Reviews present practices and explains new methods; results show its superiority; details of tube rolling.

2:15 p.m. Quality Control Parlors Q, R, S

(Auspices of Management Division)

Chairman: John Younger *Recorder:* R. E. LeBlond

1—Quality Control of Wright Aircraft Engines, by H. Emanuel, Wright Aeronautical Corporation

Problem of producer who must consider quality before all else; summary of functional organization and its interrelationships; application to small-production shop.

2—Quality Control of Hudson Motor Car Company, by V. P. Rumely, Hudson Motor Car Co.

Quality control a result of rapid developments in materials, tools, gages, fixtures, and machinery; limits and how maintained; volume production improves quality.

2:15 p.m. Power Transmission Parlors A, B, C

(Auspices of Machine-Shop Practice Division)

Chairman: O. W. Boston *Recorder:* Charles Reesey

1—A New Basis for the Rating of Roller-Chain Drives, by G. M. Bartlett, Purdue University

Horsepower ratings and analysis of bending action and friction of links; tables based on number of teeth, chain velocity, and rpm of smaller sprocket show that twice usual load can be secured with certain combinations of teeth and chain lengths.

2—The Pivoted-Motor Drive, by R. R. Tatnall, J. E. Rhoades & Sons

Theory and design; graphic method of solution; calculation of belt tension and position of pivot; comparison of pivoted-motor and fixed-center drives.

2:15 p.m. Lectures on Color Roof Garden

(Auspices of Graphic Arts Division)

Chairman: Edward Epstean *Recorder:* Frank Mills

1—Color in Use, by George L. Welp

Color principles that determine visibility, legibility, the "power" of color, and its "effect;" color from the point of view of artist, designer, and user.

2—Fundamental Research in Graphic Arts, by Charles Clarkson

2:15 p. m. TVA Session Old English Room

Chairman: W. R. Woolrich

1—Some Relationships of Industry to Agriculture and Population Adjustments, by John Ferris, Tennessee Valley Authority

2—Norris Dam and Tennessee Valley Development—Discussion of Program for Saturday Excursion

4:15 p.m. Calvin W. Rice Memorial Lecture Roof Garden

Chairman: Harvey N. Davis

1—Velox Steam Generator and Its Possibilities as Applied to Land and Sea, by Adolf Meyer, Brown, Boveri & Co., Baden, Switzerland

6:30 p.m. Dinner Roof Garden

1—The Engineer in Social Progress by Ralph E. Flanders, President, The American Society of Mechanical Engineers

Presentation of Holley Medal for 1934 to Dr. Irving Langmuir, General Electric Co.

FRIDAY, JUNE 21

9:00 a.m. Fuels Ballroom

Chairman: R. A. Sherman *Recorder:* Edward H. Mitsch

1—Radiation Intensities and Heat Transfer by Radiation in Boiler Furnaces, by H. O. Croft and C. F. Schmarje, State University of Iowa

Development of absorption calorimeter with fused-quartz window; its use in connection with series of boiler tests; checking results with formulas for computing the radiation heat transfer; new tentative formulas developed for computing radiation intensities and transfer rates.

2—Slag Tapping of Flat-Bottom Boiler Furnaces, by J. H. Strassburger, Weirton Steel Co.

Changes in design of blast-furnace-gas fired furnace necessitated by use of pulverized coal; four designs of furnace bottom tried; operating data under slag-tapping conditions.

9:00 a.m. Machine Shop I Roof Garden

Chairman: R. E. W. Harrison *Recorder:* Reuel L. Smith

1—Influence of Cutting Fluids on Tool Life in Turning Steel, by O. W. Boston, W. W. Gilbert, and C. E. Kraus, University of Michigan

Relation between cutting speed and tool life in turning tools for cutting dry, with borax water, three soluble oils, plain mineral oil, sulphurized mineral oil, soluble oil containing colloidal graphite, and plain mineral oil containing colloidal graphite.

2—Machine-Tool Electrification, by P. McShane, Westinghouse Elec. & Mfg. Co.

Application and mounting of motor and control on machine tools; reasons for special mountings; complete electrification to eliminate certain mechanical parts will reduce overall cost of tools.

9:00 a.m. Iron and Steel Parlors A, B, C

(Auspices of Iron and Steel Division and A.S.M.E. Mechanical Springs Research Committee)

Chairman: G. M. Eaton *Recorder:* H. C. Uihlein

1—Influence of Protective Layers on Life of Metals, by F. N. Speller, National Tube Co. (Subsidiary of U. S. Steel Corp.)

Principal factors that frequently control rate and distribution of corrosion; preventive measures classified; application of protective layers, with reference to protection by thin films, metallic and nonmetallic coatings such as galvanizing, paints, and lacquers, and coatings of greater thickness for underground pipe lines.

2—Cohesion and Resistance to Plastic Deformation, by D. J. McAdam, Jr., and R. W. Clyne, Department of Commerce

Relationship between these two properties as influenced by temperature, velocity of deformation, cold work, and combination of stresses; influences on ductility and energy absorption.

9:00 a.m. Graphic Arts

Busses leave Hotel Gibson for visit to U. S. Playing Card Plant and University of Cincinnati, where Graphic Arts Division will hold meeting in cooperation with Graphic Arts Research Bureau.

11:30 a.m. Lithography University of Cincinnati

Chairman: E. W. Palmer *Recorder:* D. W. Dorst

1—Lithographic Research, by R. F. Reed

Research contribution of Lithographic Technical Foundation, which began active work in 1925; includes plate making and plate control, paper making and improved register, increased knowledge of causes of deterioration of rubber blankets and methods of prolonging blanket life, and an increased knowledge of the plastometry of printing and lithographic inks.

2—Recent Developments in Lithographic Printing, by Lewis Kantrowitz, Government Printing Office

12:15 p.m. Luncheon **Mezzanine**

2:30 p.m. Aeronautic Parlors A, B, C

Chairman: E. A. Sperry *Recorder:* Bradley Jones

1—Engineering Problems in Aircraft Operation at High Altitudes, by R. E. Johnson and R. F. Gagg, Wright Aeronautical Corporation

Substratosphere flight discloses no insurmountable problems and indicates less than expected increase in airplane performance; advantages increase roughly in proportion to length of flight between scheduled stops; complications in cabin pressure control and ventilation; problem of an engine to give satisfactory performance above 15,000 ft.

2—Blind Landings, by A. E. Hagenberger, Wright Field

2:30 p.m. Machine Shop II Roof Garden

Chairman: E. A. Muller *Recorder:* Forrest E. Cardullo

1—Today's Machine-Tool Problems, by Sol Einstein, Cincinnati Milling Machine Co.

Fixture and tooling problem; proper selection of machines and methods for best production and at lowest cost; difficulties with designs which fail to consider existing machine tools; tolerances and finishes required in modern machine shop; development of new cutting-tool materials.

2—Why Standardization Pays, by John Gaillard, American Standards Association

Enables industrial concern to adapt itself more easily to varying market requirements; standardization as a dividend-paying proposition.

3—Economic Situation in the Machine-Tool Industry, by H. H. Lind, National Machine Tool Builders Association

Contributions of machine-tool industry to modern life; economic factors influencing the industry; obsolescence and replacement; machines and unemployment.

2:30 p.m. Fuels Ballroom

Chairman: C. A. Joerger *Recorder:* Joseph W. Bunting

1—The Possibilities of Pulverized Coal for Small Boilers, by James W. Armour, The Riley Stoker Corporation

Progress in application; comparison of stoker-fired and pulverized-coal-fired boiler, showing relative cost of installation and operation; trend of development in equipment used with pulverized coal-fired small boilers.

2—Discussion of Pulverized-Coal Firing in the Cincinnati Territory, led by J. C. Hobbs, Diamond Alkali Co.

2:30 p.m. Graphic Arts University of Cincinnati

(Auspices of Graphic Arts Division)

Chairman: George Carter *Recorder:* Anthony George

1—Recent Photomechanical Developments, by J. S. Mertle

Resolving power of photographic plates and films; nature and use of stripfilm, high-light negatives; diffraction theory of halftone; use of fine halftone screens; projection in platemaking; modern collotype; relief plates from photographic film; color photography and color reproduction (Mimeograph process); electrolytical dot etching; deep-etch plates in lithography; rotogravure and chromium plating of cylinders, wirephoto.

2—The following subjects will either be discussed or papers will be presented by title:

Precision Plate-Making Process; High-Speed Newspaper Printing; Zinc Die-Casting Plate-Making Process; Newspaper First Impression Offset; Color-Measuring Devices; Paper and Its Relation to Printing.

6:00 p.m. Informal Party

SATURDAY, JUNE 22

Trip to Norris Dam and Tennessee Valley Development.

WHAT'S GOING ON

This Month's Authors

RALPH E. FLANDERS, President, A.S.M.E., has achieved national recognition for his writings on economics and his contributions to economic thought. Mr. Flanders' comments are based on his observations as a machine-tool manufactuer, as a former president of the National Machine Tool Builders Association, and as a member of several boards advisory to the Administration on the NRA.

ERNEST N. JENNISON has been engaged with Warner and Swasey on problems involved in the design of telescopes and their appurtenances. FRANK L. BRADLEY, member, A.S.M.E., writes of his personal experiences with flue-gas scrubbers at the Forstmann Woolen Company, where he serves as plant engineer. Comments on the engineer's English come with authority from JOHN C. FRENCH, librarian of the University Library, and formerly professor of English at The Johns Hopkins University. Preventing the corrosion of metal surfaces has been an important study with F. N. SPELLER, director of metallurgy and research of the National Tube Company, and member, A.S.M.E. Numerous constructions of flat bottoms for slag-tap furnaces were tried at the Weirton Steel Company's plant and are described by J. H. STRASSBURGER, its combustion engineer. The résumé of forty years of comparative measurements on the weir and venturi meter at the Alden Hydraulic Laboratory, Worcester, has been prepared by Prof. C. M. ALLEN, former Council member, A.S.M.E., and his associate, L. J. HOOPER, junior, A.S.M.E. LINCOLN FAIRLEY is a member of the Economics Department of M.I.T. and has specialized in labor relations.

Actions of A. S. M. E. Executive Committee

AT ITS meeting of April 20, the Executive Committee of the Council acted on a number of individual cases of membership status, and routine financial matters referred to it by the Finance Committee. It voted to appoint Roy V. Wright acting treasurer during the period of Mr. Oberg's absence from the country from May 15 to July 1.

Upon recommendation of the Committee on Relations With Colleges, a student branch was authorized at Northwestern University, Evanston, Ill.

The following appointments were reported for record: Safety Committee, John B. Chalmers; Committee on Policies and Budget, James W. Parker; Advisory Board on Professional Status, James H. Herron, chairman; Guggenheim Board of Award, Thos. A. Morgan (4 years); Division of Engineering and Industrial Research, National Research Council, Bert Houghton.

National Applied Mechanics Meeting, June 18–19

THE Third National Applied Mechanics Meeting will be held at the University of Michigan, Ann Arbor, Mich., on June 18 and 19, under the auspices of the Detroit Section, the Applied Mechanics Division, and the University. The program is given in detail below.

Excellent accommodations have been arranged and a special program prepared for the women attending the meeting. Reservations should be sent direct to Dr. S. Timoshenko at the University. All registrants have been granted the privileges of the Women's League and the Men's Union, both of which are conveniently near the meeting places. These include the use of all public lounges, card rooms, restaurant, and grill. At the Women's League, a room with twin beds and bath will be \$2 a night a person. At the Men's Union single rooms are \$2 and up, double rooms, \$4 and up. Charges for meals are moderate.

TUESDAY, JUNE 18

9:00 a.m. Registration opens, Room 348 West Engineering Building

10:00 a.m. Elasticity—I

Chairman: J. E. Younger

1—Thermal Stresses in Plates, by J. L. Maulbetsch
2—Temperature Stresses in Flat Rectangular Plates and in Thin Cylindrical Tubes, by J. P. Den Hartog
3—Photoelastic Studies in Stress Concentrations, by M. M. Frocht

2:00 p.m. Strength of Materials

Chairman: F. B. Seeley

1—Fatigue Tests of Specimens With Cold-Worked Surface, by O. J. Horger
2—The Effect of a Hole in Carbon-Steel and Nickel-Steel Boiler Plate Under Pulsating Tensile Stress, by H. F. Moore and J. S. Ingles
3—Some Further Studies of Stress Concentration and Its Effect in Certain Fatigue Tests, by R. E. Peterson and A. M. Wahl

4:00 p.m. to **6:00 p.m.** Inspection of Materials-Testing Laboratory of University of Michigan

4:00 p.m. to **6:00 p.m.** Informal discussion of symbols in engineering mechanics

6:30 p.m. Joint dinner at the Men's Union of the University of Michigan. After dinner J. Ormondroyd will give a talk on "Some Thoughts on the Teaching of Dynamics to Engineering Students."

WEDNESDAY, JUNE 19

9:30 a.m. Vibration and Dynamics

Chairman: B. L. Newkirk

1—Impact on Beams, by H. L. Mason
2—Lateral Oscillations of Rail Vehicles, by B. F. Langer and J. P. Shamberger
3—Method of Balancing Reciprocating Machines, by W. E. Johnson

2:00 p.m. Elasticity—II

Chairman: S. C. Hollister

1—Deflection and Strength of Cantilever Plates Loaded by Concentrated Forces, by C. W. MacGregor
2—Stability of Compressed Elastically Supported Plates, by A. J. Miles
3—Functions for Solution of Three-Moment Equation for Beam Columns With a Non-Uniform Load, by J. E. Younger
4—Creep of Metals, by A. Nadai

4:00 p.m. to **6:00 p.m.** Inspection of Engineering and Physics Laboratories of University of Michigan

Consumers Goods Industries Group Enlarged

THE Metropolitan Junior Group of The American Society of Mechanical Engineers, that is investigating the consumers goods industries for the purpose of uncovering new fields of endeavor for the young engineers, has increased in size, and interest in its work is extending to other localities.

Because of the enlargement of this group and the increase in correspondence, proceedings are becoming more formal. L. G. Bohn has been appointed corresponding secretary, and O. Kleinman, recording secretary.

Normally the work of the committee would be suspended during the summer, but the members of the group feel that they have uncovered such useful information that they wish to continue toward their conclusions without interruption. Hence the group will meet on the first Monday of the month in July and August. Regular bi-monthly meetings will be resumed in September.

Naumberg Honored for Aid to Blind

THE Franklin Institute of Philadelphia, Pa., has announced the award for 1935 of the John Price Wetherell Medal, to Robert E. Naumburg, member A.S.M.E., for his invention of the visagraph for enabling the blind to read any printed book without the aid of any other person. The award is for "an apparatus original in its accomplishments, and of unquestioned benefit to humanity."

Guggenheim Medal Awarded to W. F. Durand

WILLIAM FREDERICK DURAND, past-president and honorary member, The American Society of Mechanical Engineers, has been awarded the Daniel Guggenheim medal for 1935, "for notable achievement as pioneer in laboratory research and theory of aeronautics; distinguished contributions to the theory and development of aircraft propellers."

Gantt Medal Awarded to A. H. Young

THE Henry Laurence Gantt Memorial Medal, has been awarded to Arthur Howland Young, vice-president in charge of industrial relations, United States Steel Corporation, "for outstanding and creative work in the field of industrial relations."

Moreland to Head Electrical Department at M.I.T.

THE appointment has been announced of Edward L. Moreland as head of the department of electrical engineering, of the Massachusetts Institute of Technology. Mr. Moreland, who is senior partner of the engineering firm of Jackson and Moreland, and a member of The American Society of Mechanical Engineers, will succeed Prof. D. C. Jackson, member, A.S.M.E., who retires in June.

A.I.E.E. Meets at Cornell, June 24 to 28

THE Summer Convention of the American Institute of Electrical Engineers will be held at Cornell University, Ithaca, N. Y., June 24 to 28.

P. H. Carlin Becomes Editor of "Civil Engineering"

P. H. CARLIN has been appointed editor of *Civil Engineering*, monthly publication of the American Society of Civil Engineers, succeeding Walter E. Jessup, who has given up his work as editor in order to assume his duties as field secretary of that society.

Social Progress Institute at Wellesley

THE general theme for lectures at the Summer Institute for Social Progress at Wellesley, to be held at Wellesley, Mass., July 6 to 20, on the campus of the college, will be "Social Planning in an Age of Conflict." Engineers are invited to take part, as the engineering point of view is greatly desired. Full details of the program and application blanks may be had from the Summer Institute for Social Progress at Wellesley, 420 Jackson Building, Buffalo, N. Y.

A.E.C. News From Washington

WORK-RELIEF PROGRAM

PROGRESS under the work-relief program has been delayed during the past month. Actual starting of jobs and hiring of men still await the approval of individual projects by the new chain of Federal boards which have been placed in control.

The set-up, briefly, at this moment, starts with a Division of Application and Information, headed by Frank C. Walker, director of the National Emergency Council. Applications are passed from there to an Allotment Division under Secretary Ickes. With the President's approval, projects go to a Progress Division under Relief Administrator Harry L. Hopkins who thus is in a key position as to the supervision of actual work. Admiral C. J. Peoples, Director of Treasury Procurement, will handle purchase of materials under the Hopkins division. Under-Secretary R. G. Tugwell is expected to take over subsistence and rural community projects. Rural electrification is tentatively under Morris L. Cooke, member, A.S.M.E.

Prominent engineers in the higher command include Maj. Gen. Edward M. Markham, Chief of Engineers; Dr. Elwood Mead, Commissioner of Reclamation; and Thomas H. MacDonald, chief, Bureau of Public Roads, all on the Works Allotment Division, known as WAD. Fred Schnepfe, Director of Projects, PWA, has been named secretary. These four men are members of the American Society of Civil Engineers.

Two billion dollars are to be released from the works fund, according to present plans, for allocation to projects. This represents half of the four billion dollars that was broken down in MECHANICAL ENGINEERING, May, pages 336 and 338, and each class of work (highways, rural electrification, etc.) is assigned, for the present, one-half of the sum earmarked in the bill.

General policies stand essentially as stated last month. From recent Presidential statements, it is inferred that relatively small-scale projects, widely scattered, involving a high labor ratio, and possible of completion within a year, will be pushed forward rather than large undertakings, such as dams, where a huge sum would be spent in a restricted area on work spread over several years.

A Department of Conservation and Works is proposed in a bill sponsored by Secretary Ickes and introduced by Senator J. Hamilton Lewis of Illinois. This is designed to permit the President to institutionalize on a long-time basis some of the construction and conservation activities which have developed under the emergency units of the government.

A.E.C. ACTIVITIES

The American Engineering Council's membership continues to expand under the new plan of nominal dues for state and local organizations. Membership committees of A.E.C. are being set up in each state to encourage more groups to join and to become participants in the steps which Council is taking toward the advancement of the profession. This system of committees is preliminary to the development of Council's regional public affairs committees which will permit engineering opinion to be voiced through joint action.

A study of the civil-service system in its relation to engineers will be made by Arthur W. Berresford, past-president of A.E.C., who has consented to do this unofficially and to render an informal report as a basis for action by Council.

The Federal Committee on Apprentice Training has changed its classifications with regard to engineers in response to a request from Council. Under the apprentice listings, items formerly appeared for chemical, civil, electrical, heating, structural, and ventilating engineers. The apprentice system, with its wages lower than standard, has been applied to engineers only if students in cooperative (part-school, part-work) colleges. Mr. Morrison Handsaker, administrative assistant of the Committee, therefore consented to segregate the engineers under a separate section, specifying that apprentice training should apply only under these colleges.

The chairmanship of the A.E.C. Committee on Aeronautics has been accepted by Grover C. Loening, a pioneer in aircraft invention and president of the Loening Aeronautical Engineering Corporation. The purposes of the committee are to encourage civil aviation, promote research, and to sponsor specific improvements, such as larger airports, better technical planning of airports, speeding of air services, and coordination of Federal and municipal activities.

SURVEY OF ENGINEERING PROFESSION

The survey of the engineering profession, by the U. S. Bureau of Labor Statistics in co-operation with Council and the engineering societies, at last goes forward. Delay was occasioned first by the compilation of the unexpectedly large mailing list of 170,000 names received from engineering groups throughout the country. This work was done in New York under the direction of George T. Seabury, chairman of the A.E.C. Committee on Engineering and Allied Technical Professions. More recently, heavy pressure of Federal work has prevented the Bureau from proceeding with the study. The final plan is to complete the mailing of questionnaires by June 1. The closing date for blanks to be filled in and returned to the Bureau has been set for July 6. Andrew Fraser, formerly of Council's staff and now Assistant Chief of the Division of Wages, Hours, and Working Conditions of the Bureau, will be in complete charge.

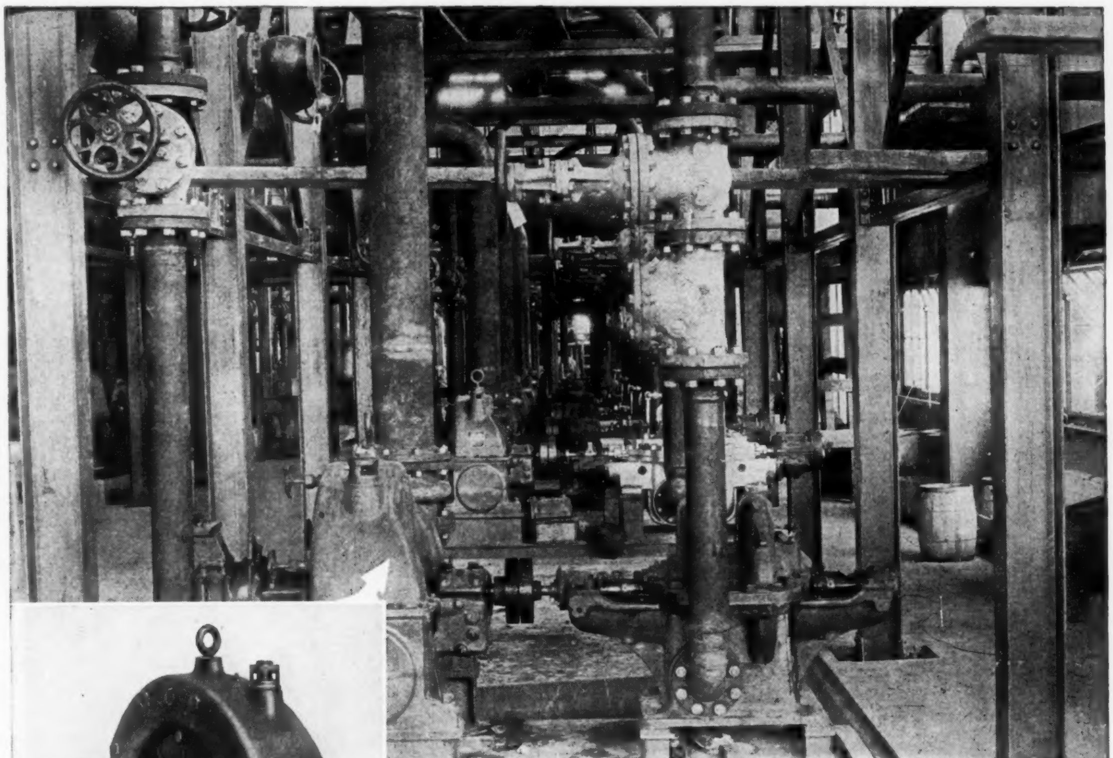
It is essential that all returns be made. If any professional engineer, or any one who in the past has qualified as an engineer, fails to receive a questionnaire by about June 10, he is requested to write to Andrew Fraser, U. S. Bureau of Labor Statistics, Department of Labor, Washington, D. C., for one of the blanks.

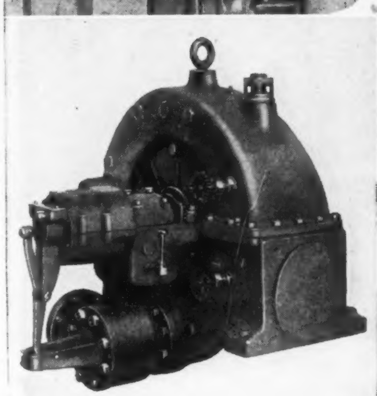
DIGEST OF BROOKINGS INSTITUTION REPORTS

A digest of the Brookings Institution reports entitled "America's Capacity to Produce" and "America's Capacity to Consume" has been

(*Continued on page 398*)

TERRY





15 TERRY WHEEL TURBINES SELECTED FOR THE NEW FREEPORT SULPHUR CO. PLANT

The Freeport Sulphur Company chose Terry turbines to drive the essential pumps at its new sulphur mining plant at Grande Ecaille, La.

These turbines employ the one-piece Terry rotor. The buckets are milled directly into the wheel so that there are no parts to work loose. The clearances are generous and the blades are double rim protected. Such design insures both reliable and efficient operation.

The Terry wheel turbine is described in our bulletin S-84. A request on your letterhead will bring a copy.

The TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.
Steam Turbines - - - Gears

T-1103

prepared by the Maurice and Laura Falk Foundation of Pittsburgh, Pa., through whose courtesy A.E.C. has copies for distribution to engineers who wish to study the results of these basic surveys.

New Curricula at Purdue

PURDUE University will offer a new curriculum in "Public Service Engineering," beginning September, 1935. This Public Service Engineering curriculum has as one of its major objectives the preparation of engineers capable of dealing with the technologic problems of government. Purdue University expects that a considerable portion of the graduates of this curriculum will enter government service as a life work.

In the Public Service Engineering curriculum, basic instruction will be given in the elements of civil, electrical, and mechanical engineering, while the requirements in science, mathematics, languages, and mechanics are the same as for the standard professional engineering curricula. Considerable attention is also devoted to government and social sciences, in order to aid the student in gaining an appreciation of the relation of engineering to the public and to its agent—the government.

Matriculation in the Public Service Engineering curriculum is limited to a small selected group of students whose record during the freshman year has indicated superior mentality and outstanding personality, as well as a decided interest in public matters.

DR. GILBRETH'S APPOINTMENT

Dr. Lillian Moller Gilbreth, consulting engineer in management, of Montclair, N. J., member A.S.M.E., has been appointed professor of management at Purdue University, effective September, 1935.

Dr. Gilbreth's duties at Purdue University will include direction of research projects in the management field, cooperation with the present staff in the teaching of industrial engineering, special conferences and instruction to those interested in management, home making and rehabilitation of crippled people, and public lectures in the field of her specialty.

INSTRUCTION IN ENGINEERING-LAW

Effective September, 1935, Purdue and Indiana Universities are cooperating in a combined course in engineering and law for the benefit of those who are interested in an engineering background for law practice relating to patents, radio, railway, and other transportation, public-utility, marine, and similar engineering problems.

The first three years the student spends at Purdue University where he devotes his time to fundamental engineering subjects as well as science and mathematics. At the end of the third year the student transfers to the School of Law of Indiana University and enters upon the regular law curriculum there. The successful completion of one year at the School of Law entitles the student to the degree of Bachelor of Science in Engineering Law from Purdue University. The LL.B. degree is conferred by the School of Law of Indiana University after two additional years.

Bibliographies Available at Library

FOR the large group of engineers who cannot visit the Engineering Societies Library because of distance or lack of time, the library maintains a service bureau to make available to each engineer the information he needs. The services of this bureau range from suggesting a book or one or two articles on a given subject to the preparation of exhaustive bibliographies for use in engineering projects or in patent litigation. A loan collection of modern American engineering books is also maintained for the convenience of members of the Founder and contributing societies.

Where bibliographies are furnished by the service bureau, the mere possession of a list of books and articles may not solve the engineers' problem. He will probably need the information to be found in literature rather than a mere list. Thus it has been necessary to extend the work of the service bureau so as to offer approximately the equivalent of a visit to the library. When bibliographies are compiled, a note is appended to each article explaining what it is about, so that the recipient of the bibliography can tell whether he needs to read a given article as a whole, in part, or not at all. When he has determined what articles he should read, if he cannot obtain them at a local library, he may send a list of them to the Engineering Societies library to have photostatic copies made. The Library is equipped to supply photoprints of all material on file. But even the possession of an exact copy of an article may be insufficient if the article is in a foreign language. In such cases the service bureau supplies exact, technically accurate translations.

It is to be noted that the service bureau has on file more than 4000 bibliographies already made up on special engineering subjects. Any of these may be procured by paying a moderate copying charge. As an example of the material contained in these lists, some of the bibliographies on various aspects of mechanical engineering are listed in Table 1.

Some of the other mechanical-engineering subjects covered or partly covered by the bibliographies already made up and on file are: Abrasives, air compressors, airplanes, annealing, ash handling, atomizers, automobile engines, bearings, belts, bimetal castings, binders, blowers, boiler compounds, boiler feedwater, boilers, brakes, briquets, clutches, combustion, compressed air, compressors, conveyors, cooling ponds, cooling towers, corrosion, crankshafts, crushers, cylinders, Diesel engines, draft tubes, driers, dust precipitators, ejectors, electric boilers, elevators, engines, fans, feed mechanisms, flame propagation, flow in pipes, flow meters, friction, fuels, furnaces, gages, gears, governors, grinding, hammers, heat exchange, internal-combustion engines, keys, lathes, locomotives, lubricants, lubrication, machine shops, machine tools, mechanical handling, mercury boilers, meters, nails, nozzles, orifices, oscillating screens, pattern making, pipe, pipe lines, pneumatic conveying, power plants, power transmission, presses, prime movers, pumping, pumps, radiators, reclaiming oil, refrigeration, remote con-

(*Continued on page 400*)

TABLE 1 BIBLIOGRAPHIES AVAILABLE IN LIBRARY

Search Number	No. of References	Copying charge	Title or subject of the search	Period covered
3920	12	$0.75	References on Wickes, Edge Moor, and Sterling boilers	1905–1924
4456	31	1.75	Marine use of pulverized coal	1925–1929
3398	26	1.75	Charcoal-iron boiler tubes	1881–1919
3907	21	1.25	Design of baffles for water-tube boilers	1915–1923
4436	120	7.00	Electric boilers	1914–1929
3963	20	1.50	High-pressure steam and high-pressure steam boilers	1920–1924
4672	41	1.75	Mercury boilers (not annotated)	1925–1932
4559	12	1.00	Comparison of coal and gas as boiler fuels	1924–1930
3571	27	2.00	Burning coke-oven gas under boilers	1912–1921
2578	10	1.00	Furnaces for green bagasse	1902–1918
1109	133	7.00	Boiler efficiency, etc.	1913–1916
4382	26	2.00	Steam injectors for feedwater	1913–1927
3913	29	2.00	Preheaters and recuperators	1907–1924
4099	176	10.00	Economizers	1908–1925
4023	7	0.50	Electric boiler-scale removal	1909–1924
3999	115	6.00	Piston rings	1896–1924
2492	58	3.50	Coiled springs	1883–1919
4392	12	1.00	Remote control	1917–1928
4615	24	1.75	High-pressure steam engines	1920–1931
3994	75	5.00	Three-cylinder locomotives	1883–1924
4379	25	1.75	Garratt locomotives	1920–1927
4431	15	1.25	Locomotive condensers	1923–1928
4500	10	0.75	Foundations for reciprocating engines	1896–1928
4043	16	1.50	High-pressure steam turbines	1923–1924
4569	28	2.00	Corrosion of condenser metals	1929–1930
4631	6	0.50	Noises in boilers	1917–1929
4685	27	1.75	Water and gas paths in steam boilers	1927–1932
4370	11	1.00	Submerged combustion	1914–1927
4487	15	1.00	Chemical regeneration of fresh steam from exhaust steam	1920–1927
4479	19	1.00	Fireless engines	1874–1888
3321	71	5.00	Flow of steam in pipes	1871–1920
4080	10	1.00	Design of impulse water wheels	1905–1923
4018	82	10.50	Hydraulic machinery and ice in hydroelectric plants	1894–1923
X	140	6.00	Tide power (partly annotated)	1895–1924

trol, riveted joints, saws, screw machines, solder, speed reducers, spinning metal, stampings, steam engineering, stuffing boxes, thermo-compressors, thermostats, tide power, tools, turbines, turbo-compressors, vacuum equipment, valves, vibrations, water power, water wheels, welding, wire, wire rope.

Any of these bibliographies may be brought up to date or extended as far back as may be required. Estimates for such work will be furnished by the library on request.

The resources of the Engineering Societies Library are thus made available to engineers everywhere. All services are rendered at cost. For information communicate with the Engineering Societies Library, 29 West 39 Street, New York, N. Y.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after June 25, 1935, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

New Applications

Adams, Francis E., Berkeley, Calif.
Anderson, George P., Philadelphia, Pa.
Biggs, William F., Clifton, N. J. (Rt)
Buerkle, Lieut. Elmer C., San Diego, Calif.
Burke, E. R., Denver, Colo.
Byle, Vernon J., Manitowoc, Wis.
Campbell, Prof. R. D., Dallas, Tex.
Carleton, Henry L., Palo Alto, Calif.
Cassell, J. L., Galveston, Tex.
Cronvich, J. A., New Orleans, La. (Prize Student)
Czerwinski, Francis A., Jersey City, N. J.
D'Arcy, Francis G., Southbridge, Mass.
Dival, Lawrence A., Berwyn, Ill.
Emerson, F. Everett, Mountain View, Calif.
Fay, Frederick J., New Haven, Conn.
Gardner, Wallace W., Lancaster, Pa.
Goldberg, Herman, Chicago, Ill.
Granata, A. J., Newark, N. J. (Rt)
Hagerty, C. C., Arlington, N. J. (Re)
Hansen, William E., San Francisco, Calif.
Harvey, Wells F., Park Ridge, Rye, N. Y.
Heede, B. M., Oslo, Norway
Hollis, R. Frank, Alton, Ill.
Houghton, C. A., East Orange, N. J. (Rt & T)
Joa, Curt G., Manitowoc, Wis.
Kenney, Roger J., Manitowoc, Wis.
Laine, Leo, Berkeley, Calif.
McConnell, Charles W., Warren, Pa.
McCullough, Joseph J., Seattle, Wash.
Muerle, Richard W., Springfield, Ill.
Murphy, Chas. G., Bronx, N. Y.
Noell, Milton J., Oil City, Pa.
Peterson, V. A., Kansas City, Mo.
Posey, Prof. Chesley Johnston, Iowa City, Iowa
Ragland, Richard K., Creighton, Pa.
Reed, J. R., San Francisco, Calif.
Reggel, Walter G. A., Huntington, W. Va.
Richards, Walter E., New York, N. Y.
Richardson, Charles H., Cambridge, Mass.
Satterfield, Howard E., Raleigh, N. C. (Rt)
Schlank, Elias, New York, N. Y. (Rt & T)
Shauer, Julius, Citein-So., U. S. S. R.
Shockley, H. W., Kenmore, N. Y. (Rt)
Smith, H. Pearson, Windsor Locks, Conn.
Sonderman, Gerhard, Stewart Manor, L. I., N. Y.
Tonkonogy, Alwin, Long Island City, N. Y.
Vlahakes, John L., Newark, N. J.
Vreeland, Milton A., Little Silver, N. J.
Ward, John E., Torrance, Calif.
Weibull, Prof. Waloddi, Stockholm, Sweden (Rt & T)
Westerberg, Charles Gunnar, Willoughby, Ohio (Rt & T)
Wilburn, Jack, Huntington Park, Calif.

Change of Grading

Transfers from Associate-Member

Greene, George F., Hempstead, L. I., N. Y.
Hardie, Philip H., Brooklyn, N. Y.
Linker, J. I., Rutherford, N. J.
Lutz, George, Brooklyn, N. Y.
Oliver, Frank J., Jr., Detroit, Mich.
Palmer, Dean Delos M., Ottawa Hills, Ohio
Sawyer, R. Tom, New York, N. Y.

Transfers from Junior

Epley, Frederic I., New York, N. Y.
Harlow, James H., Lansdowne, Pa.
Hopkins, W. E., New York, N. Y.
Mathews, Ralph T., Durham, N. C.
Peck, Clarence E., Wilkinsburg, Pa.
Putnam, John L., Brooklyn, N. Y.
Rublee, Edmund O., Cambridge, Mass.
Schneider, Frank H., Royersford, Pa.
Searles, Elwood F., Fair Lawn, N. J.
Supové, Lawrence, Portland, Oregon

A.S.M.E. Transactions for May, 1935

THE May, 1935, issue of the Transactions of the A.S.M.E., contains the following papers:

Rolling-in of Boiler Tubes (FSP-57-7), by F. F. Fisher and E. T. Cope
Steam-Turbine Leaving Losses and Vacuum Corrections (FSP-57-8), by Linn Helander
Principles Underlying the Rational Solution of Automatic-Control Problems (FSP-57-9), by Sergei D. Mitereff
Application of the Elastic-Point Theory to Piping Stress Calculations (FSP-57-10), by S. W. Spielvogel and S. Kameros
The Loading and Friction of Thrust and Journal Bearings With Perfect Lubrication (MSP-57-2), by H. A. S. Howarth

Discussion
On previously published papers by N. P. Bailey, H. J. Sloman and A. C. Barnhart, and C. B. Millikan

Discussion of papers in the May issue of Transactions will be received until July 10, 1935.

Education and Training

A paper entitled "Analysis of Occupations of College Grade Compared to the Engineering Profession" prepared by Marion B. Richardson and presented under the auspices of the Committee on Education and Training in Industry at the 1934 Annual Meeting of the A.S.M.E. is available for distribution in mimeographed form. Copies may be secured upon request.

Midwest Engineering, Power Exposition, Oct. 14 to 18

IT has been announced that the Seventh Midwest Engineering and Power Exposition will be held in Chicago, October 14 to 18, 1935. The Exposition will be devoted to the fields of power generation, distribution, and utilization.

Books Received in Library

(*Continued from page 389*)

Mitteilungen aus den Forschungsanstalten GHH-Konzern, Vol. 3, Part 7. V.D.I. Verlag, Berlin, February, 1935. Paper, 8 × 12 in., illus., diagrams, charts, tables, 3.15 rm. Three reports are included in this pamphlet. The first, by Dr. K. Schlaefke, discusses the changes in the design of high-speed internal-combustion engines that have resulted from the development of the Diesel automobile engine. In the second, Johann Uebing describes a new curve for railroad cross-overs and turnouts which is more easily produced in the shop than the usual forms. The third paper, by Hermann Kopp, presents some considerations upon cylinder castings for air-cooled engines, with special reference to the use of copper-bearing cast iron.

Practical Solution of Torsional Vibration Problems. By W. K. Wilson. John Wiley & Sons, New York, 1935. Cloth, 6 × 9 in., 438 pp., illus., diagrams, charts, tables, $7. This book is intended to assist designers by presenting the principles and computation details of torsional vibration in a manner suitable for everyday reference. The material and arrangement are the results of several years of experience and the methods presented have been tested in practice. Numerous examples, selected from marine, electrical, and automobile-engineering practice are worked out to illustrate the use of the methods.

Tables and Other Data for Engineers and Business Men. Compiled by members of the College of Engineering of the University of Tennessee. University of Tennessee Cooperative Book Store, Knoxville, 1935. Leather, 3 × 6 in., 139 pp., tables, $0.75. A convenient vest-pocket volume containing a selection of mathematical, mechanical and electrical tables and formulas constantly used by engineers.

Water Supply in Buildings. By A. W. Moseley. Mumm Print Shop, Evanston, Ill., 1935, Paper, 6 × 9 in., 91 pp., figs., diagrams, charts, tables, $1.15. Methods and data for working layouts of water supply; probability applied to determination of loading in piping; contamination due to cross-connections; rate of flow required by fixtures; combined demand rates; flow diagrams; overlapping; pipe sizes; loops of pipe; fittings and valves; water meters; gravity and compression tanks; water hammer; determining size of air chamber as shock preventer.